TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. IX No. 4. APRIL, 1932. PRICE 6d.

CONTENTS.

	PAGE.
Sea Island Cotton	93
Books Received	94
The Cacao Industry of Trinidad	95
Reviews	100
Tomato Diseases in Trinidad	101
A Suggested Practical Method for Measuring Molasses Exhaustion	106
Cultivation Experiments with Sugar-Cane....	120
Cotton Notes	126
Coffee Bean Disease	127
West Indian Notes	128
Chemical Notes	130
Crop Products Manufacture	131
Luminosity of Fire-Flies	131
Trend of the Markets	132

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183.

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

SEA ISLAND COTTON.

THE serious plight of Sea Island Cotton has recently been viewed with alarm by the growers and by others interested in the industry. The present situation is said to have been brought about by the accumulation of invisible and visible stocks of Sea Island Cotton in the United Kingdom, by the apparent general lack of interest shown by the "trade" in the article and by the expansion, in spite of repeated warnings, of production in certain of the British West Indies. These factors, to which must be added the general depression in world trade have led to a severe fall in the demand for the product and in its market value. The Empire Marketing Board who have for some time past realised the gravity of the situation convened two meetings, one in November, 1929, and the other in July, 1931, to enquire into the problems of the industry. Prominence was also given in February, 1931, by the West India Committee to Sea Island Cotton exhibits at the Textile Exhibition held in the White City. As a result of the activities of these two Bodies invaluable information has been collected on the position of the article in the United Kingdom and it now remains for the producers themselves to devise the necessary means for placing the industry on a sounder basis than it is at the moment. Much is expected, therefore, of the forthcoming Conference of Sea Island Cotton Planters which will be held early this month in Barbados and which should afford an opportunity for a frank discussion of the present situation.

The cultivation of Sea Island Cotton in the British West Indies dates back to 1903, when Sir Daniel Morris distributed for the 1904 crop a considerable quantity of seed which he had secured from the Sea Islands of South Carolina. The production of the crop in these Islands has since been maintained at an average of over 5,000 bales a year. After 1918, when the American Sea Island crop of the Carolinas was wiped out by the boll weevil, the world's supply of Sea Island Cotton, with the exception of Fiji which produces a small quantity and of Porto Rico, whose cotton does not appear to come into direct competition with West Indian cotton, became almost entirely confined to the British West Indies. Thus, with almost a world monopoly, the West Indian industry flourished until after the War. It is true that during the War some difficulty was experienced in shipping the cotton produced but the accumulated stocks were eventually disposed

of during the boom period of 1919-1920. From 1921 the position gradually began to change and in common with other commodities it was found that more Sea Island Cotton was being produced than consumed. Advice was given by the Fine Cotton Spinners' and Doublers' Association to reduce the acreage planted but in spite of this, the annual production has been maintained. More recently, however, substantial reductions have been made. On more than one occasion also the same Association bought up surplus stocks in order to clear the market and enable the growers to rid themselves of the previous year's crops which were being held for sale. The position at present is that there is a considerable surplus of cotton in the hands of the brokers while it has been estimated that the unsold cotton held by growers and their brokers and the unused cotton held by the Fine Spinners was equal to several years' consumption. Prices have thus not only fallen considerably but the crop is now finding a very slow and reluctant market.

There are several reasons for the decline in the demand for Sea Island Cotton. Most of this cotton, being of special strength, length and fineness, has been absorbed in the lace, very fine woven fabrics and fine hosiery trades, and in the manufacture of motor tyres, mail bags and electric insulations. During the past few years, as a result of changes in women's fashions, its use in lace and fine cotton fabrics has been restricted, while the specialised nature of its market and its high price have militated against its extended use in the motor industry. Cheaper substitutes such as artificial silks, have replaced the fabrics made out of Sea Island Cotton, while Egyptian Sakel Cotton has provided a substitute for many industrial purposes and also for the manufacture of certain fine fabrics. As a result, much valuable and highly specialised machinery which was adapted for using Sea Island Cotton has been broken up altogether and sold for scrap values, while much of the remainder has been converted for utilising Sakel.

Although the demand in certain trades for Sea Island Cotton has fallen off, recent investigations have revealed that further changes in fashion may, in all probability, result in the utilisation of larger quantities of fine yarns in the manufacture of lace and that there may be a slight improvement in the use of Sea Island for very fine woven fabrics. Another interesting source of demand, though still small, is for covering insulated electric wires, especially the gauges employed in wireless sets. The hosiery trade, however, offers the greatest possibilities of development and this, not so much in England as in Germany, but possibly also in the United States where it is suspected that Sea Island Cotton is being used in larger quantities for hosiery yarns.

Any future improvement in the situation of the Sea Island Cotton Industry, as it finds itself to-day, will depend on the steps taken to regulate production and to stimulate demand. If these should fail it may be found necessary to resort to the cultivation of an alternative type of cotton. In the meantime a more healthy relation between supply and demand must be established before any extension of the crop can be thought of. In view of the present outlook and the moderate demand for the article the producers would be well advised to arrive at some kind of agreement by which production could be controlled. There has been little co-ordination so far between the Islands in this matter and it should be considered in all its aspects by the Conference. With regard to demand, efforts should be made to explore every new use for Sea Island Cotton and to improve the present organisation for marketing the product which might conceivably be simplified to the mutual advantage of the growers and manufacturers. It has been suggested that such objects might best be achieved by the formation of a West Indies Sea Island Cotton Growers' Association which would not only control production but also seek to expand outlets for the product. Further, such an Association might collect and disseminate statistical information, carry out propaganda, and generally do such work as would be of help to the industry as a whole. The position of the industry, in spite of various enquiries, still remains obscure and there is at the present moment much need for closer co-operation between the growers in the several islands and amongst the growers and manufacturers. Without this co-operation, Sea Island Cotton, in the face of existing competition, will find it difficult to regain its former position in the world markets. The Conference should afford the opportunity for revealing the situation in its true light and for taking practical steps to overcome the difficulties under which this West Indian industry is now labouring.

BOOKS RECEIVED.

We have to acknowledge, with thanks, the receipt of the following books which have been presented to the Library :—

AGRICULTURE.

The Agricultural Policy in South Africa, by H. D. Leppan, pp. 102. *The Central News Agency, Johannesburg, South Africa*, 1931. 6*s*.

Waste Products of Agriculture, A. Howard and Y. D. Wad. pp. 167, 7*s*. 6*d*. *Oxford University Press*, 1931.

ENTOMOLOGY.

Handbook of Insects and other Invertebrates of the Hawaiian Sugar-Cane Fields, F. X. Williams. pp. 400. Illustrations 41. *Hawaiian Sugar Planters Association*, Honolulu, 1931.

SOILS.

Soil Conditions and Plant Growth, New Edition. E. John Russell. pp. 636, 21*s*. *Messrs. Longmans Green, Ltd.*, 1932.

SUGAR.

Modern Milling of Sugar-Cane, F. Maxwell. pp. 415. Figs. 249, 50*s*. *Norman Rodger*, 1932.

THE CACAO INDUSTRY OF TRINIDAD.

SOME ECONOMIC ASPECTS.

Part I.

Scope of Investigation.

By C. Y. Shephard.

Foreword.

Agriculture is primarily a business. (3) (4) The principal aim of the agriculturist is to earn profits, and when this possibility permanently ceases, his interest in agriculture, for all practical purposes, comes to an end. Research in the natural sciences has made notable contributions to the economic welfare of the agriculturist, and to mankind as a whole. Investigations in agricultural economics are of such recent origin that there is but little actual achievement to advertise the utility of the subject. Although the biologist and agricultural economist seek the same ultimate end, they approach it from rather different aspects. The biologist is concerned chiefly with the scientific aspects of agricultural problems. He seeks a solution by such means as the improvement of varieties, the technique of cultivation and manuring, and the control of pests and diseases, which are designed generally, though not invariably, to increase gross returns. The agricultural economist, on the other hand, is interested primarily in the influence of these, and other, factors on net returns, or profits. These two aspects are not invariably compatible, since an increase of gross returns may be accompanied by diminished profits, but the biologist appreciates that such findings, while of scientific interest and value, would fail to meet the requirements of the agriculturist. In other words, he is required to consider, not merely the scientific, but also the economic aspects of agricultural problems. Similarly the scope of the economist would remain unduly restricted if he failed to consider scientific findings in his endeavours to improve the material welfare of the agriculturist. Hence, while each specialist can independently contribute a great deal to agricultural prosperity, his sphere of usefulness is greatly amplified when working in co-operation with the other. In short, the two subjects are not unrelated, but complementary.

The value of scientific research is widely appreciated, but the need for economic investigation still awaits general recognition. The progressive agriculturist no longer hesitates to obtain the aid of the biologist in problems demanding a degree of scientific knowledge beyond his own. In the business aspect of agriculture, however, he still regards himself supreme. These differences in the attitude of the agriculturist may be due, in some measure, to the difference in the working methods of the biologist and economist. The biologist may frequently have recourse to the experimental method to test the merits of his hypotheses. The economist, however, has to derive his conclusions from a study of the farm or estate as a going concern; that is, an entity which he may not manipulate on experimental lines. He is frequently, therefore, unable to study a single variable factor under controlled conditions, and generally cannot assess the influence of known but uncontrollable factors. This lack of a ready means of demonstrating the value of his conclusions has restricted the opportunities of the economist to prove his utility. There is, however, a large and useful field to be explored by the team-work of the economist and biologist, for it has been shown that the two aspects are complementary. It is probable that advances in agricultural economics may most usefully be pursued along these lines. For this reason the investigations of the Department of Economics into the Trinidad cacao industry have been conducted in close collaboration with biologists. Experience has already demonstrated that the work of the one will greatly facilitate the investigations of the other.

Objects.

In framing the scope of the investigations of the Department of Economics into the Trinidad cacao industry, the following main objects were kept in view:

(1) To obtain reliable data regarding the economic organisation of the industry.
(2) To determine the general financial condition of the industry.
(3) To ascertain the cost of producing cacao.
(4) To establish detailed standard costs, in order to enable the individual planter to compare the results of his own estate with both similar and dissimilar groups of estates.
(5) To ascertain those factors primarily responsible for the success or failure of estates.
(6) To provide a means of comparing the organisation, yields, costs of production, &c., of the Trinidad industry, with similar industries in other parts of the world.
(7) To provide problems suitable for investigation by Post-Graduate students.
(8) To provide data calculated to facilitate the investigations of the officers responsible for the College Cacao Research Scheme.

Method.

Much of the published information regarding the Trinidad cacao industry has been based upon estimates, or the experiences of individual managers, or estates, and it is often either inaccurate, or of extremely limited application. It was decided, therefore, to exclude all estates

on which information was based solely upon estimates, but to include all estates for which simple and accurate records of income and expenditure were available. A printed schedule of questions, in the form of a field note-book, was used to facilitate the collection of information and to ensure consistency of records. Visits were made to a few selected estates to test the suitability of the questions. A few minor modifications were made, and the schedule was then standardised for the remainder of the investigation.* The names of estates believed to have suitable records were obtained from the Cocoa Planters' Association and the Agricultural Bank. A circular letter was sent to each owner, or manager, indicating the nature of the investigation, and suggesting a date for visiting the estate. Prompt and favourable replies were received from all but three planters, while many communicated their willingness to co-operate before they were formally approached.

1929-1930 Session.

Between October 1929 and May 1930, 252 estates were visited. The records of 36 estates were subsequently rejected because they were inaccurate, incomplete, or insufficiently detailed. Statistical data relating to the three financial years 1926-7, 1927-8, and 1928-9 were extracted from the estate books. As the estate books are not uniform, some difficulty was experienced, and a great deal of labour was involved, in allocating some of the minor items of expenditure to their appropriate heads. Since then, however, a standard estate abstract form has been drawn up to conform in outline with those in general use. This form groups the various items on a uniform basis, but permits of modification to suit the individual requirements of estates and managers. A small booklet indicates the item against which small and irregular operations and purchases should be charged, and also illustrates the method by which all items had been allocated in the field note-books and analysis sheets. Several estates have adopted this Standard Form, and it is hoped that all will follow this uniform method by the time the existing abstract books have become exhausted.

The writer was assisted by Messrs. Lock, Roddan, Scott, Stark and Steele, who were Post-Graduate students in training at the College. Each student was expected to devote two days per week to this particular subject. The investigators worked in pairs, and, as a rule, visited one estate in the morning and another in the afternoon. The schedule was usually completed in two hours, the remaining time being devoted to visits to the fields and questions of a non-quantitative nature. In a few exceptional cases the required information was obtained in less than an hour, but in others the records were so inaccessible that as many as ten days were required. Estates of the latter type were omitted at an early stage in the investigation.

*A copy of this schedule is available for inspection in the Department of Economics.

The 216 estates, whose records were used during the 1929-30 investigation, represented a total of 47,756 acres of cacao, with an average annual yield of 74,300 bags, or 12,259,500 lb. of cacao. As the total area under cacao in Trinidad was then 209,000 acres (2), the data obtained covered 23 per cent., or approximately one quarter, of the total area. The total exports of Trinidad cacao (*i.e.*, excluding the Island-Ward of Tobago) averaged 53 million lb. per annum during the three-year period under review * (1), so that the yield of the estates examined also represented 23 per cent., or approximately one-quarter, of the total exports. Gilbert's survey (which embraced the entire area under cacao) showed that the average yield per acre amounted to 255 lb†. The average yield of the 216 estates in the present investigation was 257 lb., a difference of less than one per cent. It may be claimed, therefore, that the yields obtained on the 216 estates examined are typical of the Trinidad industry as a whole.

On the other hand it cannot be maintained that the information is representative of all sizes of properties. This is clearly shown by a comparison of the number of properties visited with the total in the island in the various size classifications. Unfortunately Gilbert and the writer differ in their method of grouping, the former using the entire area of the property, and the latter the area under cacao alone. However, by suitable re-classification it is found that the present investigation includes only 12 of the 15,047 cacao properties not more than 50 acres in total area. Hence, although these small properties accounted for 94,845 acres of cacao, or nearly half the area devoted to this crop, the information obtained from them was negligible. This was primarily due to the lack of suitable records. Even among the 456 properties between 50 and 100 acres only 25 were included. Of the 585† estates exceeding 100 acres in total area, however, no less than 179 were visited. In short, the present investigation covers one-third of the total number, two-fifths of the gross area, and one-half of the area under cacao, of all cacao properties exceeding 100 acres in total area.

It has been shown that the average yield of the estates visited is the same as the average yield of the entire Trinidad industry. It will be demonstrated, later, that profits and yields are closely associated on the estates visited. It cannot be assumed, however, that the same relationship exists on the small holdings. In other words the present investigation must be regarded as concerned only with the estates, or

* The exports of cacao, over an extended period, may be considered as approximately equivalent to production, as, although some cacao is utilised in local manufacture or direct consumption, the quantity is relatively insignificant. In any single year, however, the lag between production and export (usually six to eight weeks) may cause a considerable difference, as pickings in some years are heavy, and in others light, during November and December.

† According to Gilbert's revised figures.

TABLE I.

Relation of cacao estates, of various sizes, visited, to total area in Trinidad.

Gross Acreage.	Total No.	Visited		Total Gross Acreage.	Visited		Total Cacao Acreage.	Visited.	
		No.	Per cent. of Total.		Gross Acreage.	Per cent. of Total.		Cacao Acreage.	Per cent. of Total.
0-10	10,038	—	—	62,744	—	—	36,270	—	—
11-50	5,009	12	0	99,229	353	0	58,575	323	1
51-100	456	25	5	32,162	1,927	6	19,140	1,477	8
101-200	288	52	18	41,822	7,891	19	25,174	6,337	25
201-500	221	91	41	71,045	31,012	44	39,965	21,235	53
501-1,000	65	28	43	48,629	18,999	39	22,364	11,345	51
More than 1,000	11	8	73	23,437	16,634	71	7,466	7,039	94
Total	16,088	216	1	379,068	76,816	20	208,954	47,756	23

large cacao properties, and in no way with small holdings or peasant proprietors. The lack of detailed economic information of peasant production is greatly to be regretted. The fact that reliable records are seldom maintained by the peasants necessitates a different, and more difficult, method of approach. Fortunately Gilbert's survey provides certain valuable statistical data regarding small-holders, which, it is hoped, may form the basis for a fuller examination of this important section of the industry.

1930-1931 Session.

Another six students, Messrs. Beckett, Booth, Clothier, Cook, King and Strangeways assisted the writer, during the session 1930-31, in collecting similar information relating to the financial years 1923-24, 1924-25, 1925-26 and 1929-30. Visits were confined to 126 estates to enable the investigators to make a detailed examination of certain factors revealed during the previous year, and to restrict expenditure. For these estates, comprising 32,220 acres of cacao, detailed information is available for a period of seven years. No records of the changes in the total acreage are available over this period. The average yield per acre amounted to 260 lb., and there is no reason to suppose that this figure may not be regarded as typical.

Analyses.

The information obtained during the visits to the estates was abstracted in the office and transferred to the appropriate analysis sheets. The investigators were assisted in this work by the part-time services of three statistical clerks. The enormous amount of work entailed, coupled with considerations of time and finance, made it necessary to proceed with certain analyses before the returns from some of the estates had been completed. It has not been found possible to include all these returns in the general analyses, but a brief examination of the additional material suggests that no significant differences would result.

The estates visited were first grouped into three principal districts, namely "the Northern Range", "Sangre Grande" and "Montserrat", and, in addition, four smaller and subsidiary districts, namely, "Siparia", "Talparo", "Rio Claro" and "Moruga". As there were too few estates in either the Princes Town or Mayaro areas to warrant separate consideration, they were grouped together as a fifth subsidiary group, "Princes Town and Mayaro". Details of the average expenditure, income, and profit or loss were calculated for the entire group in each district in the following three ways; per acre, per 1,000 pickets, and per bag of cacao. It should be noted that "1,000 pickets" is the local unit by which yields of cacao are measured in bags (of 165 lb.) of dry cacao. A picket is a unit for one tree, or the site if there is a vacancy. With trees planted at a distance of 12 feet × 12 feet, 1,000 pickets were roughly equivalent to a carrée, (or quarrée), an old French measure of area equivalent to 3 1-5 acres. In the absence of definite land surveys 1,000 pickets represented a convenient measure of area, and this unit is retained in deference to local custom, though all results are also calculated on an acreage basis.

In order that each planter might have an additional, and more restricted, standard of comparison, it was decided to select groups of the best and worst estates in each of the principal districts. Great difficulty was experienced in selecting a suitable criterion for distinguishing these groups. Consideration was given to the annual percentage return on the capital invested, the total profit, the profit per acre, and the cost of production per bag of cacao. A subsequent article will show that most estates were established in piecemeal fashion, and, except in rare cases, the capital invested is unknown. Consequently the annual percentage return on the capital invested cannot be calculated. Most estates close their books on 30th June, but some wait till 31st December, and a few till 30th September,

Violent fluctuations occurred in the price of cacao during the period under review, and, as a result, estates, which close their financial year at different dates, show unusually large differences in average prices, in addition to such variations as might be due to superior quality or marketing efficiency. It was decided, therefore, not to use tests, such as unit or total profit, which involve reference to prices. Moreover the area under cacao on the various estates varies from 16 acres to 2,445 acres, so that the absolute net profit would, in any case, have proved a useless criterion.

Various arbitrary modifications in these tests might have been adopted to render them suitable as a means of distinguishing the best and worst estates. It was decided to use, in preference, the cost of production per bag of cacao as the criterion. It is fully appreciated, however, that this measure is open to serious objections, as it is not necessarily related either to the number of bags sold, or to the capital invested. In this particular case, however, costs of production vary generally, though not invariably, inversely with yield, so that this method approximates to the profit per acre basis. Further, although the cost of establishing an estate by the contract system * varied with different locations, and with time, such differences were not very great. The purchase price of a cacao estate, on the other hand, varied enormously, not only with locality but also with time. Generally, however, low costs of production are associated with high yields, and it may therefore be expected that such estates will show the largest percentage return on the capital invested. Hence the cost of production per bag of cacao may be regarded as a reasonably satisfactory test, though, whenever possible the data is subjected to other criteria. In each of the principal districts, therefore, the estates were arrayed according to their cost of production, and those having the lowest unit costs, to the extent of one quarter of the total number, were grouped together as the "Best Estates". Similarly those estates having the highest costs of production, numbering one quarter of the total, were grouped as the "Worst Estates". Both these groups were dealt with in the same way as the entire group in each district, the details of the average expenditure, income, and profit or loss being calculated on the basis of (*a*) per acre, (*b*) per 1,000 pickets, and (*c*) per bag of cacao.

A similar table was drawn up for all the estates visited throughout the island. As in the case of the principal districts, details were calculated for the "Worst" and "Best" estates. It may be noted, in passing, that the "Worst" and "Best" estates in the principal districts are not necessarily included in those categories in the table containing all the estates visited. Thus one of the "Worst" estates in a good district, or one of the "Best" estates in a poor district, might fall into the "Average" group in the island taken as a whole. Similarly "Average" estates in good or bad districts might be classed with the "Best" or "Worst" groups, respectively, in the island as a whole.

For each district, and for the island as a whole, nine tables* are now available, seven dealing with each of the financial years from 1923-4 to 1929-30, one with the average of the three years 1926-7 to 1928-9, and one with the average of the seven years 1923-4 to 1929-30. On each table, appropriate columns enable the planter to insert the results of his own estate, which he can compare, and contrast, with those of the various groups.

In addition, the estates were grouped according to certain characteristics, namely, average annual rainfall, area under cacao cultivation, amounts spent per acre on cultivation, yield of cacao per 1,000 pickets, and average age of the cacao cultivation. Each group was sub-divided into classes determined by the degree possessed of the particular characteristic under consideration. For each class, details of expenditure, income, and profit or loss were calculated in the same manner as for the districts. These tables * are available for the average of the three years 1926-7 to 1928-9, and for the average of the seven years 1923-4 to 1929-30.

A complete set of these tables has been circulated to each planter who assisted the investigation. By this means object No. 4 has been fulfilled, namely, "to establish detailed standard costs to enable the individual planter to compare the results of his own estate with both similar and dissimilar groups of estates". In subsequent articles it is proposed to deal with the remaining objects.

Summary.

Agriculture is primarily a business. The chief concern of the biologist is to increase *gross returns*, and of the agricultural economist to increase *net returns* or *profit*. These two aspects are complementary.

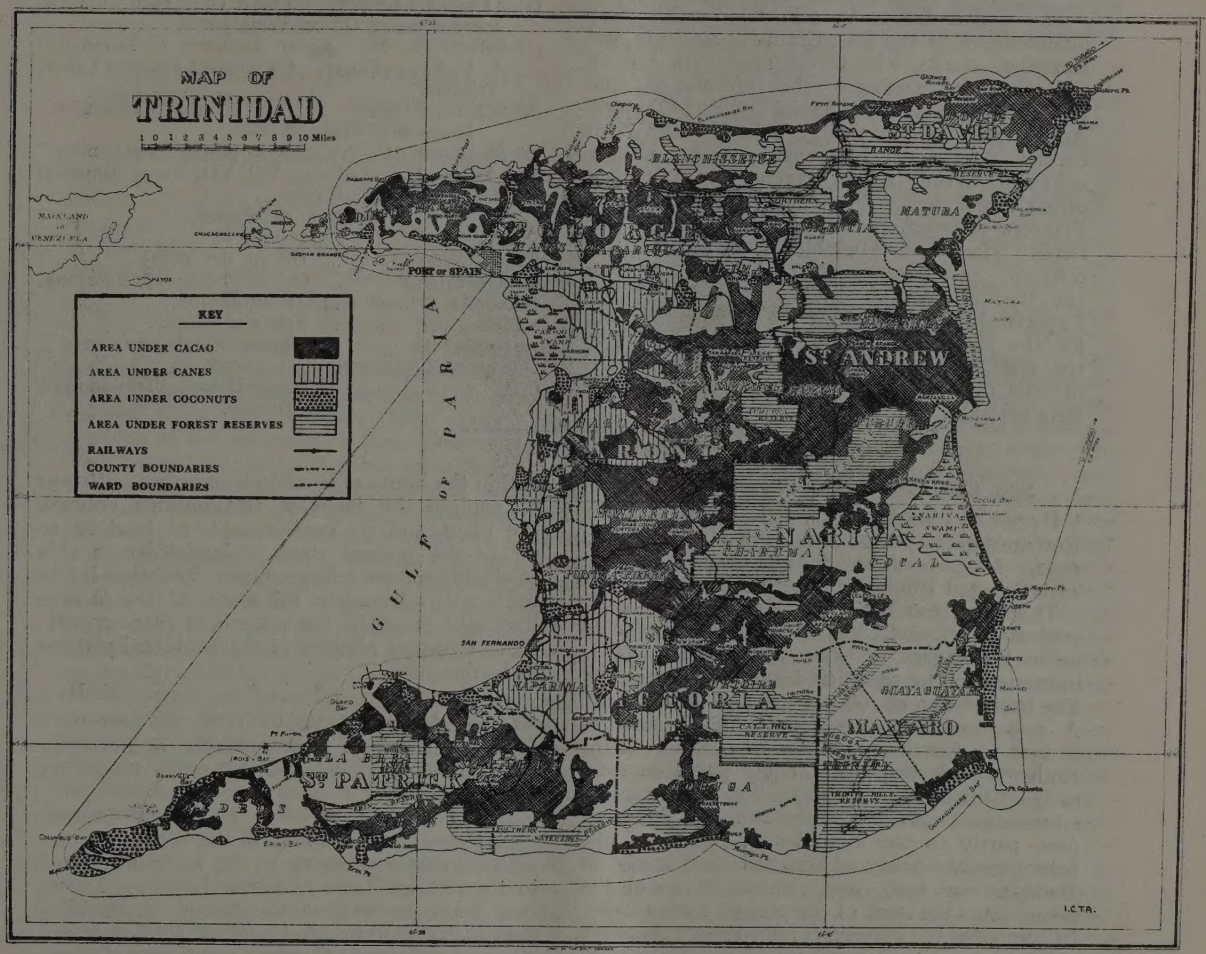
The investigations of the Department of Economics into the Trinidad cacao industry were designed to provide reliable information regarding the organisation, financial condition, and costs of production of the industry; to establish detailed standard comparative costs; to ascertain the factors primarily responsible for the success or failure of estates; to provide a means of comparison and contrast with similar industries; and to facilitate the work of the College Cacao Research officers.

Visits were made to all estates willing to provide access to reliable records of expenditure and income. In 1929-30, some 216 satisfactory records for the three financial years 1926-7, 1927-8 and 1928-9 were obtained by the writer and five part-time Post-Graduate students.

* The 'contract system' will be described in a later article.

* Certain of these tables will appear with appropriate articles. Copies of the original tables may be purchased from The Editor, *Tropical Agriculture*, Imperial College, Trinidad, B.W.I. (*See* Advertisement).

Fig I.—Map of Trinidad showing the distribution of the major crops, namely Cacao, Sugar and Coconuts.



NOTE.—*Information recently made available indicates several small deviations in the present distribution of the major crops. These differences are not of sufficient importance to warrant the preparation and printing of a new map.*

These estates represent nearly 50,000 acres of cacao, with a production of more than 12 million pounds of cacao, or approximately one-quarter of the total area and yield. No information was obtained from peasant proprietors, but it is hoped to remedy this omission in the future.

During 1930-31, some 126 records of the financial years 1923-4, 1924-5, 1925-6 and 1929-30 were obtained by the writer and six Post-Graduate students. For these estates, comprising over 30,000 acres of cacao, detailed information is available for a period of seven years.

The information was analysed with the part-time assistance of three statistical clerks. The estates were grouped into the three principal districts of the "Northern Range", "Sangre Grande", and "Montserrat", and the five subsidiary districts of "Princes Town and Mayaro", "Siparia", "Talparo", "Rio Claro" and "Moruga". Details of expenditure, income, and profit or loss were calculated for each district on the basis of per acre, per 1,000 pickets, and per bag of cacao. Similar calculations were made for one quarter of the estates with the lowest costs of production, termed the "Best Estates", and for a similar number with the highest costs of production, termed the "Worst Estates". Another table was prepared for all the estates visited grouped together.

In addition, the estates were grouped according to average annual rainfall, area under cacao cultivation, amount spent per acre on cultivation, yield of cacao per 1,000 pickets, and average age of the cacao cultivation.

A complete set of tables was circulated to each planter who assisted the investigation.

Acknowledgments.

The writer desires to acknowledge his deep indebtedness to the Post-Graduate students and statistical clerks, who co-operated with him in collecting and analysing the information, and to his colleagues at the Imperial College of Tropical Agriculture, who invariably afforded him their cordial assistance. He remains under a deep obligation to the planters, merchants, Government officials, and the Directors and staff of the Cocoa Planters' Association and Agricultural Bank who readily placed all available information at his disposal, and entertained the investigators in the traditional West Indian manner. To the Department of Agriculture he is indebted both for the valuable help afforded by members of the staff, and the sum of £100 which proved of vital importance by enabling him to get the data analysed.

Literature.

(1) "Customs Report." C.P. No. 67 of 1930. *Government Printing Office*, Trinidad.

(2) Gilbert, S. M. "Cacao Industry of Trinidad." C. P. No. 4 of 1931. *Government Printing Office*, Trinidad.

(3) O'Brien, George. "Agricultural Economics,' *Longmans, Green & Co.*

(4) Shephard, C. Y. "Agricultural Economics." *Tropical Agriculture*, Vol. VII, No. 4, Imperial College, Trinidad, 1930.

Glossary of Terms.

Fanega	.... 110 lb.
Bag of cacao	.... 165 lb. dry cacao.
One cent. (1c.)	.... One halfpenny (½*d.*) sterling.
One dollar ($1.00)	.... 4*s.* 2*d.* sterling.
1 Picket	.... Tree site.
1,000 Pickets	.... Approximately one carrée.
One quarrée (or carrée)	3 1-5 acres.
C.P.	.... Council Paper of Trinidad and Tobago.

REVIEWS.

Soil Conditions and Plant Growth.

By Sir E. John Russell, D.Sc., F.R.S. (Director, Rothamsted Experimental Station), Sixth Ed., 1932. *Longmans Green & Co.*, London. pp. 636, with Selected Bibliography. Price 21s.

This book has become the standard text for students of physiological crop ecology; it should be in the library of every agriculturist who is interested in the scientific basis of his vocation. The first edition of 168 pages, was issued in 1912. A second edition appeared in 1915; a third in 1917; a fourth edition (the first volume of the Rothamsted Monographs) of 357 pages, in 1921, and a fifth edition in 1927. The further rapid advance in knowledge of the soil and the plant (due partly to the remarkable success of the International Society of Soil Science, founded at Budapest in 1909, and revived in 1922) has necessitated the issue of the present sixth edition. In compiling his book, Sir John Russell has been aided by numerous members of his staff at the Rothamsted Station and the Imperial Bureau of Soil Science.

The subject matter includes a historical introduction, together with sections dealing with the composition of the soil and the soil conditions that control plant growth; the natural changes that the soil undergoes; the micro-organic soil population, and methods of characterising soil. Most of the important original researches that have contributed to the increasing control which man can exercise over the elusive agencies that determine the growth of plants have been reviewed and incorporated in the work. Ample bibliographical reference to these researches is provided, and numerous explanatory tables of data and illustrative diagrams are presented. The whole material is welded into an orderly and continuous account, both pleasant and inspiring to read. Sir John Russell's well-known faculty for descriptive writing, herein, is well displayed; the reviewer knows of no book in the English language which supplies within similar scope such a valuable *vade mecum* as this. The account throughout keeps well within the limits of its object, namely to attempt to explain the intricate relationships between the plant and its environment, at least in so far as the present state of knowledge is able to elucidate these relationships. Doubtless future work will adequately fill many of the *lacunae* that still occur in the science of plant-growth, so that further editions of the book will perhaps be forthcoming.

* * * F. H.

Recent Advances in Pasture Management.

By O. McConkey. Empire Marketing Board, 43. *H.M. Stationery Office*, London, 1931, pp. 43, price 1s.

Dr. McConkey reviews the recent pasture-management research work in the British Empire, with particular reference to the work in progress in research institutes of Great Britain. During two years' leave from the Guelph Agricultural College in Ontario, he studied at Cambridge, Aberystwyth, and Aberdeen, and visited many continental grassland centres. His unique position as an observer enables him to present a bird's eye view of the latest research results and their application to animal nutrition.

Most of the work in progress centres in the Hohenheim system of intensive grassland management, and the author summarises the economic and scientific factors which led to its development in Europe. By this system, rapidly growing grass is fully utilized by intensive grazing in small fields. The fields are heavily fertilized, and the stocking is arranged so that the grass is eaten down in a few days. The animals are then moved to another field, and so on in rotation, each field being allowed to rest till the grass is in full flush again. The subject has many ramifications, and most publications have dealt with one or other of the specialised branches. In this report we have a review of relevant research work in plant breeding, ecology, heavy manuring, and animal nutrition, presented in a manner which will appeal to both the stock breeder and the research worker. D. W. D.

TOMATO DISEASES IN TRINIDAD.

(*Concluded.*)

Fruit Diseases of Tomatoes.

BY

A. K. BRIANT, M.A., Dip Agric. (Cantab.), A.I.C.T.A.,
Mycology Department, Imperial College of Tropical Agriculture.

IT is usual in Trinidad to pick tomato fruits when they are full and just beginning to turn colour. They are then stored in a dark receptacle until they are ready for the market. During this storage period a number of diseases develop which are not evident on the fruit in the field.

Phytophthora sp.

This fungus is very common during the wet season on fruits which are near or touching the ground. Several unsuccessful attempts have been made to find the fungus attacking fruits high up on the plant, but infected fruit always had particles of soil adhering to their lower surfaces. This means that they had either actually touched the ground or had been splashed by rain falling on the soil. Fruits in all stages of development are attacked. The infected region consists of a brown water-soaked area which rapidly enlarges, and frequently develops signs of a few incomplete concentric rusty-brown rings. In humid conditions a white growth chiefly consisting of conidiophores and spores of the organism develops on the surface of the lesions.

The control of the disease depends chiefly on growing the fruit under satisfactory conditions. Staking or other means of keeping the fruit from contact with the soil, and encouraging free ventilation of air around the plants are to be recommended.

Bacterial Rot.

A bacterial rot of green and ripe fruit is of considerable importance in Trinidad. Diseases similar in nature have been reported in the United States, Russia and St. Vincent, and it seems that in each case, the organism responsible is identical with or closely related to *Bacillus aroideae* Towns. Nowell who reported the disease in St. Vincent (15) proved by inoculation experiments that the bacterium was pathogenic, and described the organisms as long, actively motile, rods. He suggested that the disease probably entered the fruit through bug punctures made by *Nezara* and *Leptoglossus*.

Symptoms.

The lesions usually begin where the skin of the fruit has been injured in some way, but sometimes where no injury is apparent. In the latter case they consist of water-soaked areas, usually with a definite dark green margin. As the disease advances, numerous small bubbles appear beneath the skin, which increase in size and unite together to form bubbles several millimetres in diameter. Usually the tension of the gas produced inside the fruit soon causes a rupture of the skin, and from this oozes an offensively smelling liquid. Finally the whole of the flesh inside the fruit is reduced to liquid and gas, most of which escape from the skin which remains hanging on the plant.

When infection takes place through an obvious wound, the skin of the fruit frequently splits radially, and there is therefore not so much accumulation of frothy liquid.

Infection Experiment I.

From fruit showing such symptoms a number of isolations were made by the pouring of plates, using potato-sucrose agar. In every case apparently the same bacterium was obtained. In order to prove the pathogenicity of the organism, an infection experiment was carried out in the laboratory. Twelve healthy fruits were selected, washed in alcohol, and put in lots of six into two sterilised desiccators. 5 ccs. of sterile water and a glass containing soda lime had previously been put into the bottom of each desiccator. Six fruits were then smeared with a suspension of the bacteria in sterilized water, and the remaining six were each punctured in two places with a needle previously dipped into a culture of the organism.

Eighteen hours later, the punctured fruits were conspicuously infected. Each puncture was surrounded by a dark green water-soaked area about half an inch in diameter, and very soft to the touch. The skin in some cases had split from the site of the puncture right up to the periphery of the lesion. After 24 hours the disease had further advanced, and very small bubbles of gas were visible under the skin. After 36 hours the lesions were each about one and a half inches in diameter. The bubbles of gas were numerous, and had become much larger in the centre. There were no bubbles near the periphery. On the third day about three quarters of each fruit was diseased, and the contents of one had almost completely dripped into the bottom of the desiccator. From another fruit the organism was re-obtained in culture.

The fruits which had been smeared with a bacterial suspension showed no signs of infection even after eight days. Thus it seems probable that the bacterium is a wound parasite.

Infection Experiment II.

With regard to Nowell's suggestion that the bacterium might possibly be carried from one fruit to another by sucking bugs such as *Leptoglossus* and *Nezara*, it was thought that if his suggestion was proved, the infection of apparently healthy fruit would be explained. The bacterium might be actually injected into the fruit by the proboscis of the sucking insect, or the wound made by the insect might become infected later. To test the former theory two individual bugs (*Leptoglossus balteatus*), which had been reared from eggs in the laboratory and fed continually on healthy fruit, were put to feed on one of the fruits successfully inoculated in Experiment I. Two days later they were transferred to a healthy fruit. In three days this fruit was very badly infected with the bacterium. The bugs were then transferred to two more healthy fruits in another receptacle, and in three days these also were badly infected. About a dozen other bugs from the same brood have been fed continually for about five weeks on healthy fruit without any sign of the occurrence of the disease.

From this experiment it is concluded that *Leptoglossus balteatus* is capable of disseminating the disease. Another bug which is commonly found sucking fruits in the field is *Pthia picta*, and this also is a possible vector.

Morphology and Physiology.

A study of the bacterium by microscopical and other means has been carried out with a view to identifying the organism. All the cultures with the exception of those on gelatine were kept at room temperature, and duplicate un-inoculated tubes were kept as controls in each case. The following notes summarise most of its characters.

Motile rods, occurring singly and in pairs; $.5-.85\mu \times 1.2-4.2\mu$ (one per cent. glucose broth); no spores; capsules ?; Gram positive; agar colonies round, glistening, brownish-cream to slightly opalescent; potato-sucrose agar shake, gas produced; gelatine liquified, stab crateriform, shake aerobic and facultatively anaerobic; milk coagulated becoming acid, with gas formation; broth, turbid no pellicle; nitrates reduced; indol produced; acid without gas from dextrose, sucrose, galactose and maltose; slight diastatic action; hydrogen sulphide produced.

This description differs only very slightly from *Bacillus aroideae* (11) which occurs in chains, and is Gram positive. These characters are liable to vary according to the conditions under which the organism is grown, and it seems very probable that *Bacillus aroideae* is the bacterium concerned. Further work however is being done to establish its exact identity.

Control.

As the bacterium appears to be simply a wound parasite, the control depends on preventing fruit injuries as much as possible. The control of the bugs *Leptoglossus* and *Pthia* is simplified by the fact that in the immature stages they are gregarious.

Phomopsis spp.

During the last dry season, more than 50 per cent. of the diseased fruits from which isolations were made yielded species of *Phomopsis*. In the wet season however, the incidence of this fungus was masked by the more frequent occurrence of other diseases. From the growth of the cultures it is probable that a number of strains or species are involved and as the genus *Phomopsis* has not as yet been thoroughly investigated in the West Indies, it is impossible at present to give specific names. It is not one of the genera commonly reported on tomatoes in other parts of the world.

That infection may occur in the field, is proved by the fact that the fungus has been isolated from fruits immediately after picking, but the chief damage is noticeable during the ripening period. The fungus has been isolated several times from a mycelium growing beneath the stem-buttons of apparently healthy fruits.

An infection experiment carried out in desiccators, indicated that the fungus was a wound parasite, but the fruit inoculated was rather green and except in three cases, infection was very slow and hardly typical of the disease. The experiment will therefore be repeated using green as well as more mature fruit, so that a comparison can be made of their susceptibilities. Whether the fungus is capable of infecting healthy fruit or not will also be determined.

Symptoms.

The first signs of the disease usually appear in the neighbourhood of the stem buttons. Although the skin itself is apparently not attacked, the infection of the tissues immediately underneath, produces external symptoms somewhat similar to those of the bacterial rot previously described. These symptoms consist of the formation of a dark green water-soaked area, rather watery to the touch, and usually with a definite margin. As the area enlarges, it advances more rapidly down the septa between the loculi of the fruit than elsewhere. This may be seen very readily in the case of the fruit which is grooved. Usually a number of gas bubbles collect just beneath the skin. After a few days the whole fruit becomes infected. The skin frequently bursts and shrivels, and later becomes covered with numerous black pycnidia of the organism, which exude the "a" and "b" spore-types of *Phomopsis* as a whitish ooze.

Internally the rot is not as soft as the external appearance suggests. The tissues are slightly discoloured, most of the flesh being a brownish blue-grey, and the vascular strands dark brown. The infected fruits have rather a disagreeable smell, which, however, is not as offensive as that produced by the bacterial rot.

Control.

Until more is known about the method of infection, little advice can be given beyond stating that infected fruits should be destroyed as soon as possible.

Phoma destructiva (Flowr.) C. O. Jamieson.

Besides causing a serious disease of leaves and stems as previously mentioned, *Phoma destructiva* is an occasional parasite on tomato fruits. It is of more importance during the wet season than the dry. In both Europe and America its behaviour toward the fruit is that of a typical wound parasite. Observations indicated that this was also the case in Trinidad where it is usually associated with fruits previously wounded or affected with blossom-end rot.

When cultures of the organism obtained from the fruit were compared with those isolated from the stem no differences could be observed. An experiment was therefore carried out in which fruit was inoculated with a culture obtained from the stems of seedlings.

Inoculation experiment.

Eight desiccators were washed out with alcohol, and into the bottom of each was placed 5 ccs. of sterile water and a jar containing soda lime. The fruit was immersed in alcohol for a short time, wiped, and put in lots of six into each desiccator. The following treatments were then given :—

Desiccators I and II.—Unwounded fruit smeared with spore suspension.

Desiccators III and IV.—Spores and mycelium inserted into needle wounds.

Desiccators V and VI.—Wounded controls.

Desiccators VII and VIII.—Unwounded controls.

At the end of seven days all the fruits in Desiccators I, II, V, VI, VII and VIII were still healthy. On the second day the fruit in Desiccators III and IV were showing signs of infection. The wounds had become black, and around each was a slightly dark depressed area about 3 mm. in diameter. On the third day the diseased areas were 4 to 6 mm. in diameter, rather brown in colour and slightly depressed. Three days later the lesions had enlarged to 12 to 15 mm. They were now almost black in colour, and were covered with abundant pycnidia of the fungus. From the interior of two of these fruits the fungus was again obtained in culture. The amount of depression of the lesions in the desiccators was not nearly so much as has been noticed in the case of naturally infected fruit, but allowance must be made for the fact that they were kept in an almost saturated atmosphere, and evaporation from the lesions was thereby reduced. From this experiment it may be concluded that the fungus attacks the fruit only as a wound parasite.

Symptoms.

The young spots usually appear as small, depressed, areas which are slightly water-soaked and brownish in colour. As they enlarge, the amount of depression greatly increases, and the surface becomes covered with pycnidia, visible as numerous, small, sometimes concentrically arranged eruptions. Although the lesions sometimes remain brown in colour for a considerable time, they frequently become quite black at an early stage.

Control.

The main efforts to control this disease should be directed to prevent infection of the stem and leaves, as it is from these that the fungus spreads to the fruit. It should be remembered that the organism can only infect fruit which has already been injured.

Gloeosporium sp.

A species of *Gloeosporium* has been isolated on several occasions from lesions occurring on almost ripe fruit. The amount of disease which it causes, however, appears to be fairly small.

Inoculation experiment.

To prove that the organism was actually pathogenic, an inoculation experiment was carried out in desiccators on both wounded and unwounded fruit. The experimental procedure was exactly the same as that used in the case of *Phoma destructiva* (see above). After five days all the inoculated fruits, both wounded and unwounded, had developed lesions typical of the disease. From two of these the organism was re-isolated. The un-inoculated fruits did not become infected.

It is evident from this experiment that the species of *Gloeosporium* concerned is a parasite, and that under certain conditions might be very destructive.

Symptoms.

The first sign of infection is a small sunken water-soaked spot on the fruit. As it enlarges it becomes more depressed, and the colour darkens owing to the formation of dark acervuli just beneath the skin. When these acervuli mature, however, each becomes covered with a mass of spores which impart a pinkish appearance to the whole lesion.

Control.

Remove and destroy all infected fruits as soon as possible.

Fusarium spp.

Species of *Fusarium* are commonly found on tomato fruits which show signs of mechanical or physiological injuries (due to blossom-end rot, insects, birds, &c.). No instance has been recorded where the fungus was likely to have been a primary parasite. Once its entry into the fruit is established, however, *Fusarium* is capable of causing a rot of the remainder of the fruit. Under damp conditions the surface of the infected region is frequently covered with a whitish felt-like growth of spore producing mycelium.

One culture was used in an experiment to determine whether the fungus was capable of infecting fruit other than through wounds. The experiment was carried out exactly as in the case of the experiment with *Phoma destructiva* previously described. The *Fusarium*, however, although establishing itself in the 12 wounded fruits, did not infect the 12 unwounded. The control fruits were still healthy when the experiment was terminated after six days. The *Fusarium* was re-isolated from the infected fruit.

As therefore *Fusarium* appears to be simply a wound parasite, its presence merely emphasises the importance of preventing fruit injuries.

Diseases carried by Bugs.

Numerous organisms which may be unable to infect unwounded fruit have been shown to be transmitted from fruit to fruit by sucking bugs. During the past year *Pthia picta* and *Leptoglossus balteatus* have frequently been observed to suck tomato fruits in the field. Numbers of these bugs were therefore taken to the laboratory where they were fed on healthy tomato fruits grown in an insect-proof greenhouse. In practically every instance the fruits developed internal rots. Other tomatoes obtained from the greenhouse and kept as controls, ripened without a sign of infection.

From the eggs laid by the captive bugs, numerous nymphs were hatched. Some of these were fed continually on healthy fruit, and they caused no sign of infection. Others which were fed on fruits known to be infected with the following organisms, repeatedly transmitted the diseases to healthy fruit :—

(1) *Spermophthora gossypii.*
(2) *Nematospora coryli.*
(3) *Spermophthora gossypii* and *Nematospora* together.
(4) *Bacillus aroideae* (?). (*See* Bacterial rot).

Spermophthora and *Nematospora* both cause a rather soft rot which usually becomes noticeable when the fruit is nearly ripe. The diseased areas consist of slightly discoloured water-soaked spots which enlarge until most of the fruit is involved. The skin of the fruit is not usually affected. Both these fungi are found in the fruits of various host plants, and appear to be chiefly disseminated by bugs.

Other Fungi.

The following fungi have also been found to be associated with the lesions on diseased fruits :—

Alternaria solani.
Choanephora sp. ?
Cladosporium spp.
Stigmella sp.
Peyronelia sp.

Blossom-End Rot.

This disease has from time to time been attributed to the attack of various organisms, although some workers have never accepted the theory that a parasite was involved. It is now regarded as a non-infectious disease due to interference in the physiological processes of the plant which results in the death of the protoplasm in the cells of localised areas within the fruits. The causes of this interference are apparently connected with environmental and soil factors which effect a derangement of the water balance within the plant. The disease rarely occurs where the amount of soil moisture is moderate, or where it diminishes gradually towards the end of the growing season. On the other hand its occurrence is common in hot climates when the supply of soil moisture is intermittent, or suddenly reduced after a period of plenty. Brooks (5), however, also found that the disease could be induced by excessive moisture. Other factors which may influence the incidence of blossom-end rot are high temperatures and aridity of the atmosphere which would increase loss of water from the leaves by transpiration, high soil temperatures, and the abundance or deficiency of certain salts in the soil.

In Trinidad no instances of fruits being affected with blossom-end rot have been observed by the writer during the present wet season, although a careful search has been made. During the past dry season, however, the disease was prevalent in most districts.

On a small plot which was planted up with four repetitions of each of 16 different tomato varieties, it was observed that the incidence of blossom-end rot was most prevalent among the large fruit varieties. The variety Bonny Best was very susceptible. Other varieties moderately affected included John Baer, Stone, Bloomsdale and Marglobe. On the other hand the varieties which produced smaller fruit such as Cheshunt Hybrid, Grand Rapids, Every Day, and Best of All, appeared to be immune. Although this apparent association of small fruited varieties of tomatoes with resistance to the disease was observed by the writer independently, it has previously been suggested by a worker in Kansas (13).

Symptoms.

The first evidence of the disease is usually the appearance of a dark green water-soaked area near the blossom-end of the fruit. This area varies considerably in size from less than a centimetre up to about ten centimetres in diameter. The water-soaked appearance is confined to the tissues immediately under the skin, and even in an advanced stage the disease does not affect the fruit very deeply. The affected inner region which usually becomes somewhat flattened or sunken, gradually darkens to a brownish-black colour, while the margin is frequently outlined as a rusty-brown ring. The vascular bundles are usually visible through the dead skin as a dark reticulum.

In texture the affected tissue is typically firm and more or less leathery, as if the cells had been killed and dried up. The diseased area is occasionally invaded by various fungi which may spread beyond the margin of the blossom-end rot lesion to cause a secondary rot of the fruit.

The symptoms may appear on fruits when they are very young, but usually they are at least an inch or so in diameter. When nearly mature fruits are affected, the damage is usually slight, and little more than a scorched or scurfy appearance is the result.

Prevention.

As it is probable that some varieties of tomatoes are more resistant than others, an attempt should be made to obtain varieties which combine resistance with other good qualities.

Conditions which are liable to cause a water deficiency in the plant, such as high temperatures, and low humidities of both the atmosphere and the soil, should be avoided. This may be done by selecting soils which are not liable to dry out, and by planting at the most favourable season of the year. If irrigation or watering is practised, it must be done thoroughly and regularly, so that a continuous uniform growth of the plants is ensured.

Blossom Drop.

Tomato flowers are very liable to be shed by the premature development of the abscess layer in the pedicel, as a reaction to various environmental and physiological factors. Although the actual reasons for shedding are little understood, it is usually ascribed to occur as the result of fungal infection, or of unfavourable conditions of temperature, soil fertility or soil humidity.

Of the fungi which attack the flowers probably *Cladosporium fulvum* is the most destructive, but it has not yet been seen causing flower infection in Trinidad.

The influence of temperature (either direct or indirect) appears to be of considerable importance. Although the optimum temperature-range of the soil for the growth of tomato plants as reported by Clayton (7) is 77°F. to 86°F., the optimum range for fruit production is probably much lower than this. Pritchard and Porte (17) found that in the United States the highest yields of tomatoes were obtained from those States where the average daily temperature was 65°F. or below. Other factors such as soil fertility, &c., may, however, affect the yield in the different States, but their figures indicate that some correlation at least exists between temperature and yield.

In addition to possible fungal infections and physiological disturbances, a considerable amount of flower destruction is caused by *Contarinia lycopersici*, an account of which is given below.

Contarinia lycopersici.

Contarinia lycopersici is a small midge which has previously been reported in St. Vincent (18). During the past year it has been noticed in Trinidad to cause considerable damage to tomato flowers especially during the wet season. There are periods when it is difficult to find a flower which is not infected. The midge is very small, and lays its eggs in the evening in the young flower-buds. From these eggs small white larvae emerge, as many as eight or ten in a single flower. The larvae feed inside the anther cone, frequently damaging the style and ovary. When mature they are bright yellow in colour, about a millimetre in length, and capable of hopping, by which means they probably reach the soil for pupation. As a result of injury the flowers usually wither and drop. Sometimes, however, the damage may not be sufficient to cause the abscission of the flower, and a damaged ovary may continue to develop. The dissection of numerous flowers has resulted in the observation that this probably does occur, and that it is responsible for a commonly occurring malformation of fruit, which will therefore be described. The lesions may be seen on fruit of all ages, and occur chiefly in the wet season corresponding with the period during which the fly is prevalent. The fruits are very irregular in shape, possessing deep, simple or branched depressions, usually near the blossom-end, and sometimes almost girdling the fruit. These depressions probably represent areas where the skin has been injured when the fruit was very young, and which have since become protected by the formation of a corky-brown callus. As the latter is incapable of growth, further growth of the rest of the fruit exaggerates the depression, and frequently causes it to crack so that the seeds are exposed. Although the cracks are quickly protected by further callus formation, they frequently allow the entry of fruit-rotting organisms. Even if infection does not take place, the fruits are usually unfit for market.

To corroborate the view that the larvae of *Contarinia lycopersici* are responsible for the above symptoms, investigations are being carried out in the Department of Entomology of this College.

Acknowledgment.

The writer wishes to express his thanks to Dr. H. R. Briton-Jones whose advice and criticism have proved invaluable during the course of these investigations.

References.

1. Alston, R. A.—Memorandum on Panama Disease. *Journ. Board Agric.*, British Guiana, 20: pp. 88-90, 1927.
2. Ashby, S. F.—A Bacterial Wilt-disease of Bananas in Trinidad caused by Bacterium solanacearum. E. F. Smith. *Trop. Agric.* 3: pp. 127-129, 1926.
3. Bergey, D. H. *et al.*—Bergey's Manual of Determina ive Bacteriology. *Williams & Wilkins*, Baltimore, 1923.
4. Bertus, L. S.—Sclerotium rolfsii in Ceylon. *Ann. Roy. Bot. Gard.*, Peradeniya, 11: pp. 173-187, 1929.
5. Brooks, Charles. Blossom End-rot of Tomatoes. *Phytopath*, 4: pp. 345-374, 1914.
6. Clayton, E. E.—The Relation of Soil Moisture to the Fusarium Wilt of the Tomato. *Amer. Journ. Bot.*, 10: pp. 133-146, 1923.
7. Clayton, E. E.—The Relation of Temperature to the Fusarium Wilt of the Tomato. *Amer. Journ. Bot.*, 10: pp. 71-87, 1923.
8. Committee on Bacteriological Technic. Manual of Methods for Pure Culture Study of Bacteria. *Society of American Bacteriologists*, Geneva, N.Y., 1930-31.
9. Edgerton, C. W. and Moreland, C. C.—Tomato Wilt. *La. Agric. Exper. Stat. Bull.*, 174. 54 pp., 1920.
10. Elliot, J. A. and Crawford, R. F.—The Spread of Tomato Wilt by Infected Seed. *Phytopath*, 12: p. 428, 1922.
11. Elliott, Charlotte.—Manual of Bacterial Plant Pathogens. *Balliere Tindall & Cox*, London, 1930.
12. Jamieson, Clara O.—Phoma destructiva, the cause of a Fruit Rot of the Tomato. *Journ. Agric. Res.* 4: pp. 1-20, 1915.
13. *Kansas Agric. Exper. Stat.* Director's Rept., 1926-28, p. 33, 1928.
14. McWhorter, F. P. and Parker, M. M.—Fusarium Wilt of Tomato in Virginia. *Virginia Truck Exper. Stat. Bull.*, 64, pp. 661-674, 1928.
15. Nowell, W.—Disease of Crop Plants in the Lesser Antilles. *West India Committee*, 14, Trinity Sq., London, 1924.
16. *Ohio Agric. Exper. Stat. Bull.*, 431, 180 pp. 1928.
17. Pritchard, F. J. and Porte, W. S.—The Relation of Temperature and Humidity to Tomato Leaf-spot. (Septoria lycopersici Speg.) *Phytopath*, 14: pp. 156-169, 1924.
18. *Rept. Agric. Dept.*, St. Vincent, 1910-11, pp.20-21, 1911.
19. Rorer, J. B.—A Bacterial Disease of Bananas and Plantains. *Proc. Agric. Soc.*, Trinidad and Tobago, 10: pp. 109-113, 1910.
20. Sherwood, E. C.—Hydrogen-ion Concentration as related to the Fusarium Wilt of Tomato Seedlings. *Amer. Journ. Bot.*, 10: pp. 537-553. 1923.
21. Small, T.—Tomato "Mildew" or Leaf-mould. 14th *Ann. Rept. Cheshunt Exper. Stat.*, 1928. pp. 45-62. 1929.
22. Stair, E. C., Brown, H. D. and Hienton, T. E.—Forced Ventilation as a means of controlling Tomato Cladosporium and Septoria in Hot-beds. *Phytopath*, 18: pp. 1027-1028, 1928.
23. Wedgworth, H. H.—Wilt-resistant Tomato Varieties in 1927. *Quart. Bull.*, Mississippi State Plant Board, 7: pp. 3-4, 1927.
24. White, R. P.—Studies on Tomato Wilt caused by Fusarium lycopersici Sacc. *Journ. Agric. Res.*, 34: pp. 197-239. 1927.
25. White, R. P.—Tomato Wilt Disease. *Kansas Ag. Exp. Stat. Circ.*, 140, 5 pp. 1928.

TRINIDAD FUNGI.

Copies (price 2s. each) of a list of TRINIDAD FUNGI compiled by C. A. Thorold can now be obtained on application to the Editor of this Journal.

A SUGGESTED PRACTICAL METHOD FOR MEASURING MOLASSES EXHAUSTION.

BY

J. G. DAVIES.

Department of Sugar Technology, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

I.—Introduction.

A RELIABLE and ideal method for measuring molasses exhaustion has not yet been evolved. Such a method, to be satisfactory, must be rapidly and easily applicable in the factory laboratory. The method should consist of the statistically calculated relationship between two variants, one of which is considered as controlling the degree of exhaustion (The "Exhaustion Factor", which should be measured in terms of a non-sucrose component of the molasses) and the other, as a measure of this degree (The "Exhaustion Measure" which should be expressed, wholly or in part, in terms of sucrose). In considering an Exhaustion Factor, that is, the known or determined variant in the relationship, it is generally agreed that, of the normal impurities present in molasses, certain of them tend to increase the solubility of sucrose, others to decrease it, while the remainder exert no effect. These differences in behaviour must, therefore, be taken into account. The problem obviously concerns material of a very different nature from pure sucrose in aqueous solution containing in addition one other substance. In this case, the yield of sucrose, if the solution is supersaturated, may be easily calculated by reference to published data. Molasses, however, cannot be treated in this manner, because the composition of each of the component classes of impurities is liable to wide variation, and furthermore, each component of a class may or may not exert a different effect on the solubility of sucrose. The Exhaustion Factor should not be based, therefore, on data concerning a component of molasses which varies in composition, and whose normal constituents are known to exert different effects on the solubility of sucrose.

The Exhaustion Measure constitutes the unknown variant, and should be amenable to rapid calculation from the known variant. In order to determine whether the calculated value approximates to the actual value or not, the Measure must obviously be such that it may very easily be determined in the laboratory. The Measure need not be concerned solely with sucrose, but other components of the molasses may be taken into account, provided it is known that they are fundamentally important in their effect on sucrose solubility, and also that any variation in their composition will not effect the significance of the calculated relationship.

Methods for measuring Molasses Exhaustion so far suggested all present one or more of the above named objections. This paper is of a preliminary nature, since the procedure set out later as furnishing a reliable method, is based on the observation, obtained from four years data from one factory, that the mean value, Ash per cent. Final Molasses, does not change significantly from one crop to the next. Hence considerations of the effects of ash (a component which is known to exert profound effects on the solubility of sucrose and to vary widely in composition) may, under these conditions, be eliminated. It has been found possible to introduce another factor, namely moisture, which varies in amount but not in composition, and to obtain a correlation which, considered statistically, is very highly significant. This correlation was found to yield equally good results when applied to one year's data from another factory.

II.—Review of the Literature.

The so-called "Mechanical Theory" was the first attempt to explain failures to extract residual sucrose from exhausted molasses. It was based on the argument that the high viscosity of molasses prevented further sucrose crystallization. Since the time when this suggestion was advanced, a large amount of research on the subject has been prosecuted, and it is now generally agreed that the following factors influence molasses exhaustion :—

1. Concentration of Solutes.
2. Ash Content.
3. Reducing Sugar Content.
4. Organic Non-Sugars Content.
5. Temperature.

Geerligs (1) first demonstrated that the Mechanical Theory is untenable, by showing that, in highly viscous solvents, any sucrose that is capable of crystallizing will eventually separate. Hence the effect of viscosity is merely to prolong crystallization. Geerlig's molasses theory is based on the theory of sugar-salt complexes, in which reducing sugars are supposed to be able to take the place of sucrose. This conception led to his suggesting that the factor governing the extent to which a molasses may be exhausted is the "Glucose-Ash Ratio".

Van der Linden (4) suggested that molasses may be regarded as an ordinary saturated solution and, having regard to the effects of reducing sugars on the solubility of sucrose (2), he states (3) that the most important factors influencing molasses exhaustion are reducing sugars and ash contents, thus confirming Geerlig's conclusions.

Sylmans (5) believes that the ash content has little or no effect, and that the most important factor governing the exhaustibility of molasses is the reducing sugar content. In place of

Geerlig's "Glucose-Ash Ratio", he suggested "Glucose per cent. Water" as an exhaustion factor. This factor was generally in use up to 1929, but its application did not explain the unsatisfactory exhaustion of molasses in certain of the Java factories.

More recently, Thieme (6) has published the results of investigations of a similar nature to those undertaken by van der Linden. His work is based on the results of the analyses of molasses from 19 different Java factories, and his conclusions, which are regarded as providing a reliable method of measuring molasses exhaustion, are based on statistically calculated relationships. The study of statistics has made rapid strides within recent years, and it is now possible to obtain a measure of the relationship between one variant and another (*a*), in order (*i*) to determine whether this relationship is statistically significant (*b*), (*ii*) to calculate the average change in value of one of the variants with unit change in value of the other (*c*), and (*iii*) to estimate the standard deviation of the result of this calculation (*d*). The results obtained by Thieme were the first published attempt to correlate statistically an Exhaustion Measure with an Exhaustion Factor.

A table was presented which shows the correlation coefficients for several different Exhaustion Factors with each of two Exhaustion Measures. The Exhaustion Factors applied by Thieme were (1) Glucose per cent. Non-Sugar; (2) Glucose-Ash Ratio; (3) Ash per cent. Non-Sucrose; (4) Alkali (as oxides) per cent. Non-Sucrose; (5) Alkali (as sulphates) per cent. Non-Sucrose. The Exhaustion Measures were (*a*) per cent. Sucrose at 81° Ref. Brix., and (*b*) Purity at 28 (Water per cent. Water+Non-Sucrose). Thieme's table is reproduced herewith (Table 1).

Thieme suggested that, from the practical point of view, the best correlations to use for the determinations of the degree of exhaustion of molasses are (*a*) Ash per cent. Non-sucrose and per cent. Sucrose at 81° Ref. Brix, and (*b*) Ash per cent. Non-Sucrose and Purity at 28 (water per cent. water +non-sugar). He tested these correlations by investigating the effect of addition of alkali salts to a molasses, and found that the experimental results agree very closely with the calculated values. With the aid of his exhaustion factor, he was able to show a similarity between cane molasses and beet molasses. He states that the "saturation lines" which he obtained may only be explained as being due

Table 1.

Composition of Non-Sucrose.	Measure of Exhaustibility.	Correlation Factor. (r).	Average Error. (m).	Reliability r : m.	Regression Coefficient.
(1) Glucose per cent. Non-Sugar ..	(a)	−0.31	±0.21	1.5	−0.116
	(b)	−0.30	±0.21	1.4	−0.091
(2) Glucose—Ash ratio	(a)	−0.74	±0.10	7.4	−3.585
	(b)	−0.74	±0.10	7.4	−2.843
(3) Ash per cent. Non-sucrose ..	(a)	+0.81	±0.08	10.0	+0.467
	(b)	+0.84	±1.07	12.0	+0.385
(4) Alkali (as oxides) per cent. Non-Sucrose	(a)	+0.81	±0.08	10.0	+0.733
	(b)	+0.85	±0.06	14.0	+0.615
(5) Alkali (as sulphate) per cent. Non-sucrose	(a)	+0.81	±0.08	10.0	+0.386
	(b)	+0.86	±0.06	13.8	+0.320

(*a*) This is expressed as the "Correlation Coefficient" (r) the value of which is never greater than 1.00. The coefficient may be either positive or negative, depending on whether one variant increases with increase in the other (positive) or increases with decrease in the other (negative). The greater the numerical value of the coefficient the closer the relationship between the two variants.

(*b*) The degree of significance of a correlation coefficient depends upon its numerical value and the number of pairs of variants (n).

The significance is estimated by comparing the observed result with a pre-determined minimum value set out in a table 11) for different values of P. P indicates the number of times in 100 that the relationship might be due to chance. For example, assume that there are 20 pairs of variants (n) and that the observed correlation co-efficient is 0.510 (r). In order that the relationship may be due to chance less than five times in 100, the coefficient must be numerically greater than 0.4277, and to be less than once in 100, the coefficient must be numerically greater than 0.5368. The observed value lies between these two, hence the relationship might be due to chance less than five in 100 but more than one in 100. It is statistically significant.

(*c*) A measure of the average change in one variant with unit change of the other is given by the "Regression Coefficient" (b). By means of the "Regression Equation", an estimate may be obtained of one variant when the other is known.

(*d*) The Standard Deviation gives a measure in the same units of the scatter of individual values. A value exceeding the Standard Deviation might be due to chance about once in three trials while twice the Standard Deviation is exceeded only once in 22 trials.

The method for calculating these statistics is set out in the Appendix.

to both organic and inorganic non-sugars, but that in beet molasses the proportion of one to the other is higher than in cane molasses. The value of the Ash per cent. Non-sucrose figure for a typical cane molasses is ±20.0 while for a typical beet molasses it is ±30.0. A series of abnormal cane molasses, from the Eastern districts of Java, provided a transitory form with an Ash per cent. Non-sucrose value lying between these two limits and saturation lines were presented to illustrate this peculiarity.

Objections are raised against the use of Thieme's factor in practice since, firstly, it is necessary to carry out ash determinations and, secondly, the molasses must be brought to equilibrium at 81° Ref. Brix. in order to determine the sucrose concentration. The latter objection is the more serious, because a period of several days must elapse during which the sample is stirred, while calculation of this value will lead to erroneous results. A similar criticism is levelled at Thieme's (7) suggested arbitrary exhaustion measure of "minimum purity", although this will prove of extreme importance when a time lag does not interfere with the value of the results.

Further, while the correlation coefficient shown (+0.81) indicates that the two variants are closely related, only 66 per cent. of the total variation in per cent. sucrose at 81° Ref. Brix can be explained by variation in Ash per cent. Non-sucrose. Thieme does not record the standard deviation of the regression coefficient in his paper, but from his data, it may be shown to possess a value of ±0.14 (t=3.3). While this indicates that the regression coefficient is significant (*a*), it would be inadvisable to make practical use of the coefficient because of the magnitude of its standard deviation. An inspection of his correlation diagram shows that at about 21 Ash per cent. Non-sucrose, for example, values for per cent. sucrose at 81° Ref. Brix vary from 30 to 35. This variation is very much larger than the laboratory error in determining the per cent. sucrose at 81° Ref. Brix. A similar spread on either side of the regression line will also be observed in the Alkali (as oxides) per cent. Non-sucrose correlation diagram.

In reviewing the literature on exhaustion factors published to date, it is noticed that concentration is seldom taken into account as a variable factor. Correlations are suggested which include glucose (reducing sugars), ash, &c., but satisfactory practical results are seldom obtained although the general effects on the solubility of sucrose of these constituents are known. This is probably due to concentration dominating any other one variant, and is demonstrated by the result of Thieme's suggesting an exhaustion factor which involved constant moisture, and his obtaining a significant correlation coefficient by this means. All future exhaustion measures, therefore, should either be reckoned on a similar basis of constant moisture content, or should attempt to introduce it as a variant.

An entirely satisfactory exhaustion measure has not yet been formulated because, from the factory point of view, correlations so far suggested are either not statistically significant, or the necessary laboratory operations are lengthy, so that a result cannot be obtained in a reasonable time.

III.—Collection of Samples and Analytical Results.

McDonald (8) has published and discussed the results of analyses of weekly composite samples of final molasses, obtained from an efficient factory (Factory A) operating in Trinidad. These samples were collected during the crop season of 1928, and, by arrangement with the Factory Staff, further and similar samples were collected during the crops of 1929, 1930 and 1931. The work reported herein is based on the analyses of all of these samples.

The analyses performed on the collected samples included :—

1. Total Solids (by drying).
2. Degree Brix (Refractometer).
3. Brix (Spindle).
4. Apparent and True Sucrose.
5. Reducing Sugars.
6. Sulphated Ash.
7. Alcogel.
8. Pectin.
9. Furfural - yielding substances, calculated as Pentosan.
10. Nitrogen (Kjeldahl)
11. pH value. (Electrometric.)
12. Conductivity, of 50 per cent. and 5 per cent. Solutions.
13. Surface Tension (by the drop weight method).
14. Viscosity.

Those results of direct interest to the present investigation are set out in Table 2. The analyses were carried out about a month or so after each sample had been collected.

IV.—Statistical Examination.

In examining the results of these analyses, it may be observed that, although there is a certain amount of variation in ash per cent. during any one crop, the mean ash per cent. does not fluctuate very much from one year to the next. It was therefore interesting to determine whether the differences in the mean ash percentages are significant or not. The results of this test are tabulated in Table 3.

The test indicates that, in spite of seasonal fluctuations in rainfall and temperature, the mean ash per cent. final molasses for any one factory, grinding cane from approximately the same area each year, does not fluctuate to any significant extent. Under these conditions, therefore, it may be assumed that the effect of an unvarying ash content on exhaustion of molasses from one crop to the next will be constant. The fluctuations in the ash content during any one crop period are not very great, since S.D. per cent. mean for the four crops is approximately 9 per cent. In considering the question of the factors governing the exhaustion of molasses, from the

(*a*) "t" is the ratio of the observed value to its standard deviation, and for the observed value, *i.e.*, the regression coefficient, to be significant, "t" must be greater than 3.0.

Table 2.

Sample No.	Ref. Brix.	Per cent. Sucrose.	Per cent. Red Sugars.	Per cent. Moisture.	Per cent Sulph. Ash.	Sucrose on 100 Water.	Total Sugars on 100 Water.
1928.							
1	82.4	32.23	23.12	17.6	9.94	183	314
2	81.5	32.41	19.50	18.5	9.59	184	289
3	80.8	32.75	23.40	19.2	8.71	171	293
4	81.2	32.68	23.50	18.8	9.80	174	304
5	81.9	31.71	24.50	18.1	10.14	175	316
6	82.5	31.61	23.89	17.5	9.98	180	317
7	82.2	33.53	24.80	17.8	9.29	188	327
8	82.0	33.37	23.40	18.0	9.34	185	309
9	82.2	33.03	22.73	17.8	9.83	185	313
10	81.9	34.12	21.55	18.1	10.00	188	307
11	80.8	33.15	21.65	19.2	10.65	173	285
12	79.0	38.73	16.57	21.0	9.76	184	263
13	80.4	35.16	17.98	19.6	10.34	179	271
14	80.5	35.24	19.06	19.5	10.44	181	279
15	79.4	34.13	17.85	20.6	10.46	175	264
16	79.0	39.45	15.62	21.0	9.88	188	263
17	79.6	36.06	15.71	20.4	10.46	180	257
18	81.2	36.56	17.43	18.8	10.84	195	288
1929.							
1	79.2	34.13	18.89	20.8	10.59	164	255
2	81.5	31.16	22.21	18.5	11.03	168	288
3	80.0	30.58	22.11	20.0	10.50	153	263
4	81.2	30.53	22.57	18.8	10.65	163	283
5	81.7	31.69	24.88	18.3	9.87	173	309
6	79.2	31.24	22.87	20.8	9.00	156	266
7	79.8	30.88	24.40	20.2	8.96	153	274
8	81.6	32.83	24.64	18.4	8.34	178	312
9	81.0	33.73	22.67	19.0	8.96	177	296
10	80.1	32.30	22.09	19.9	9.11	162	273
11	76.7	32.89	17.41	23.3	10.20	141	219
12	77.3	31.22	18.55	22.7	10.70	137	219
13	77.7	34.59	18.61	22.3	11.77	155	238
14	76.0	32.23	18.75	24.0	11.53	134	212
15	76.1	32.39	17.49	23.9	12.72	135	208
16	74.6	31.40	17.00	25.4	12.98	124	191
17	74.2	32.03	14.46	25.8	13.84	124	180
19	80.0	34.73	15.50	20.0	13.32	174	251
20	80.0	34.02	15.46	20.0	14.25	170	246
1930.							
1	77.4	29.85	17.68	22.6	11.00	132	210
2	78.7	29.39	18.13	21.3	11.83	138	223
3	79.0	31.52	19.59	21.0	11.45	150	246
4	80.0	29.82	21.52	20.0	10.68	149	257
5	81.0	31.15	22.44	19.0	9.10	164	284
6	81.0	31.14	23.44	19.0	10.08	164	287
7	80.9	31.85	22.25	19.1	9.99	167	283
8	81.0	31.82	21.52	19.0	10.59	167	280
9	80.0	32.51	20.83	20.0	9.90	160	263
10	80.6	32.17	21.43	19.4	9.94	165	286
11	81.2	32.44	20.67	18.8	9.48	172	283
12	80.4	31.21	20.04	19.6	10.18	159	262
13	81.3	36.12	19.59	18.7	10.14	193	298
14	78.4	29.94	19.74	21.6	10.43	138	230
15	84.6	34.86	17.86	15.4	11.46	226	342
1931							
7	82.2	33.67	22.85	17.8	9.59	206	317
9	81.3	33.89	23.74	18.7	9.55	181	306
10	82.2	34.33	23.90	17.8	9.45	186	328
11	82.7	34.93	23.06	17.3	9.31	202	335
12	80.9	34.20	22.67	19.1	8.81	179	308
13	81.9	34.88	23.22	18.1	8.98	193	321
14	82.2	33.85	22.02	17.8	10.01	190	314
15	80.6	31.80	24.02	19.4	9.38	164	288
16	81.6	34.13	20.36	18.4	10.69	186	296
17	81.8	33.59	20.03	18.2	10.93	185	294
18	82.7	34.97	19.50	17.3	11.17	202	315
19	82.2	35.34	18.84	17.8	11.12	199	304

TABLE 3.

Test of Significance of Difference of the Mean Ash Percentage.

Crop.	Ash %.	D.F.	S.D.	Variance.	t.
1—1928	9.97	17	±0.63	0.3942	(2—1) 1.9 Not significant.
2—1929	10.96	18	±2.20	4.8266	(2—3) 1.0 do. do.
3—1930	10.42	14	±0.76	0.5504	(2—4) 1.8 do. do.
4—1931	9.92	11	±0.84	0.7152	

Table 4.

FACTORY A.—DATA.

	No. pairs.	Correlation Coeff.	Regression Coeff.	X=
Per cent. Moisture (Y) and Sucrose on 100 parts water. (X)	64	−0.84	− 8.77±0.07	342.89−8.77 y
Per cent. Moisture (Y) and Total Sugars on 100 parts water (X)	64	−0.94	−17.34±0.04	617.86−17.34 y

Table 5.

FACTORY B—DATA.

	No. Pairs.	Correlation Coeff.	Regression Coeff.	X=
Per cent. Moisture (Y) and Sucrose on on 100 parts water (X)	14	−0.72	− 9.99±0.2	359.0−9.99 y
Per cent. Moisture (Y) and Total Sugars on 100 parts water (X) ..	14	−0.98	−21.89±0.04	714.0−21.89 y

point of view of one factory alone, it may therefore be considered feasible to eliminate the ash as a variant, and to assume it to be constant in accordance with the above considerations. This leaves two important variants to be dealt with, namely concentration, or moisture content, and reducing sugars content. The following correlations involving these two factors were therefore calculated :—

(1) Per cent. Moisture and Sucrose on 100 parts water (Diagram shown in Figure 1).

(2) Per cent. Moisture and Total Solids on 100 parts water (Diagram shown in Figure 2).

The summarized results are shown in Table 4.

Fisher's (11) table for testing the significance of an observed correlation shows that for n=60 and P=0.01, the coefficient must be greater than 0.3248. Each of the correlation coefficients obtained are therefore significant, and 88 per cent. of the variation in Total Sugars on 100 parts water could be accounted for by variation in per cent. Moisture, when ash content is constant.

The high significance of the correlation coefficient and low standard deviation of the regression coefficient indicates that, as far as this particular factory is concerned, a practical relationship has been found which should be of considerable use in judging the degree of exhaustion of final molasses. It was fortunate that data were also available giving the analyses of weekly composite samples of final molasses from another efficient factory (Factory B) working in Trinidad. The data covered one crop of fourteen weeks. If, therefore, a similar highly significant correlation coefficient and regression coefficient were obtained with such a small number of pairs, the value of the correlation as a practical measure of the exhaustion would be very much enhanced. The results for Factory B are presented in Table 5, and the correlation diagrams are shown in Figure 3.

Fisher's table shows that both these correlations have a significance greater than 1 : 100. The data indicate that 96 per cent. of the variation

FIGURE 1

CORRELATION DIAGRAM OF SUCROSE ON 100 PARTS WATER – % MOISTURE
FINAL MOLASSES—FACTORY A

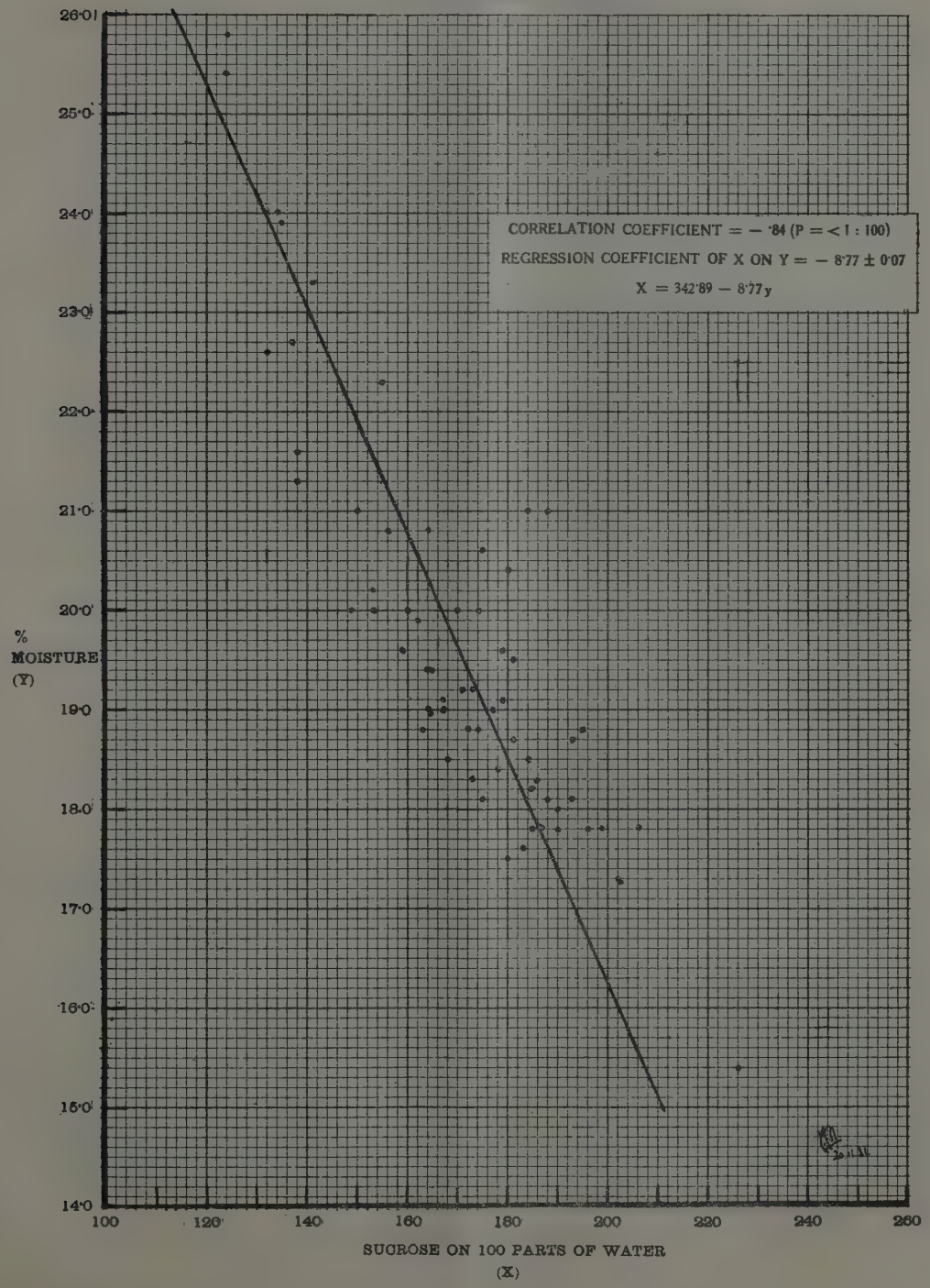


FIGURE 2.

CORRELATION DIAGRAM OF TOTAL SUGARS ON 100 PARTS WATER – % MOISTURE
FINAL MOLASSES—FACTORY A

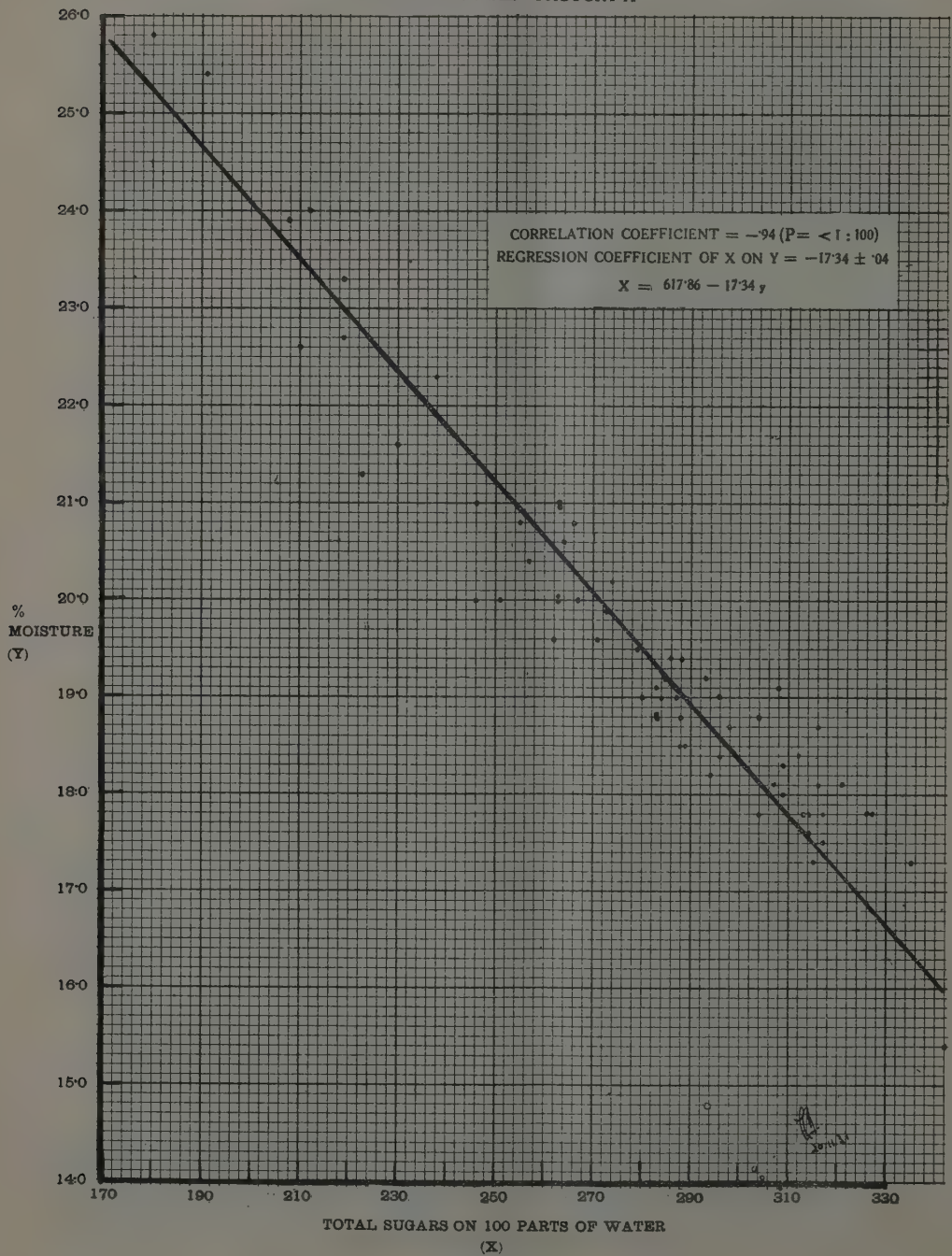


FIGURE 3.

CORRELATION DIAGRAMS

FINAL MOLASSES—FACTORY B

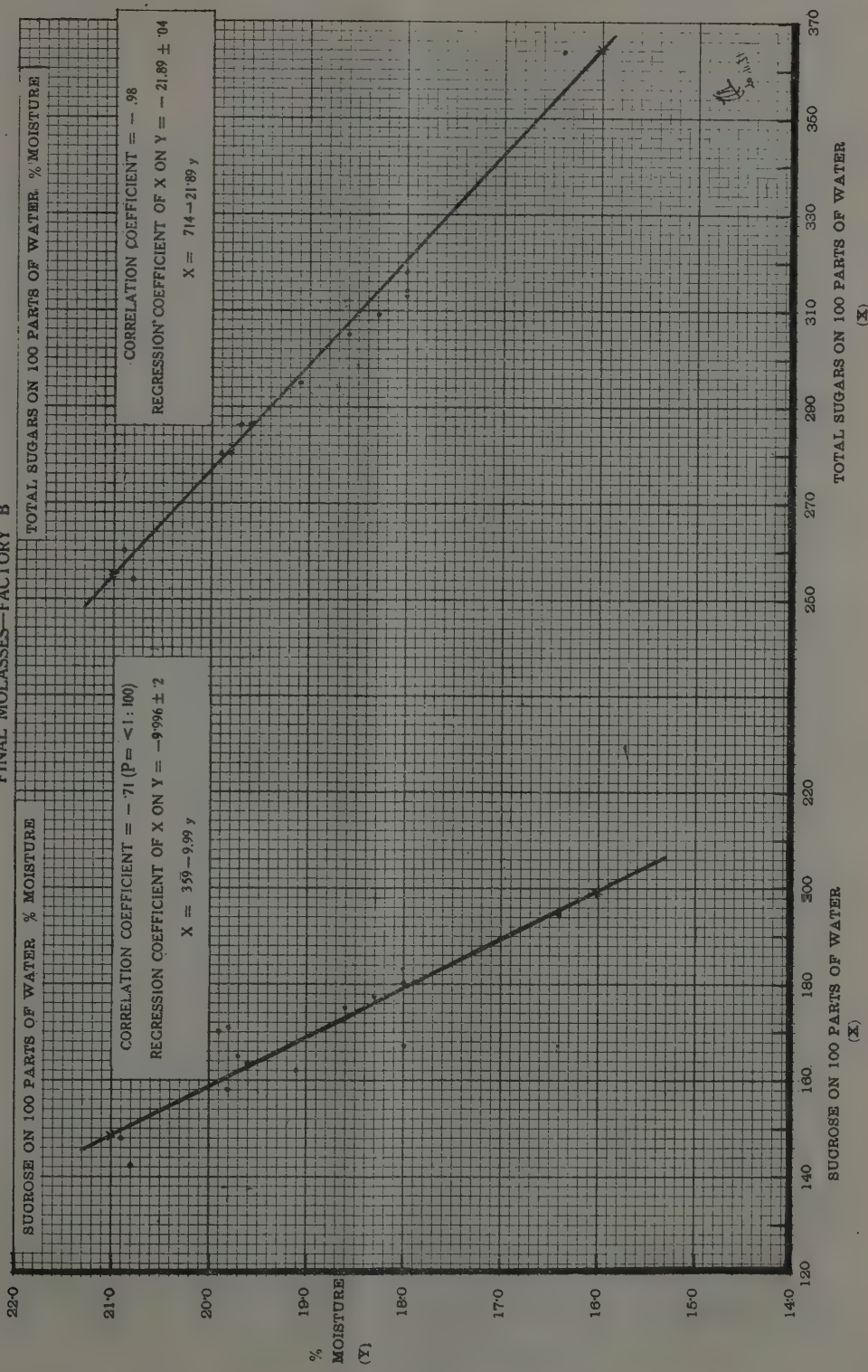
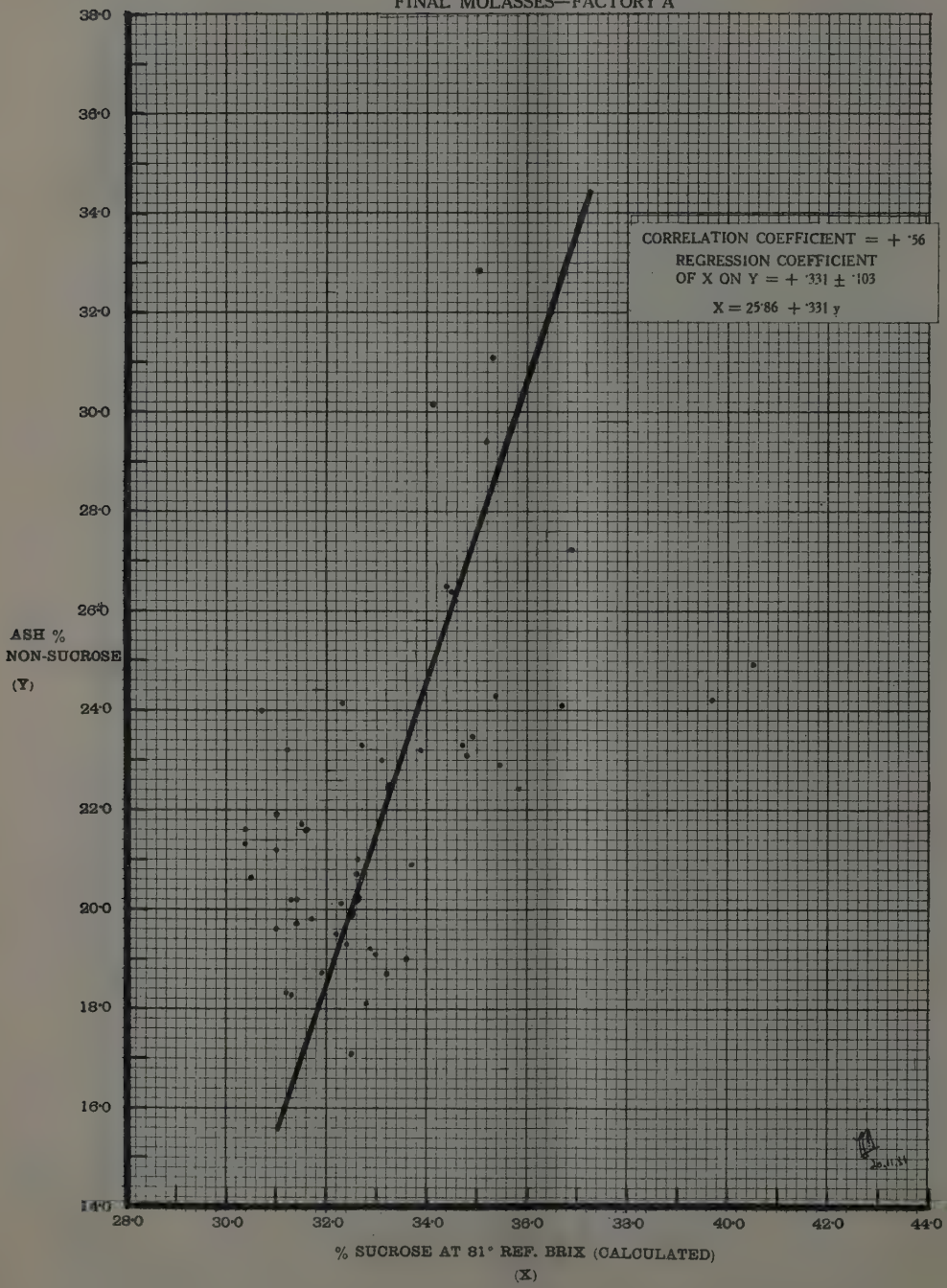


FIGURE 4.

CORRELATION DIAGRAM OF % SUCROSE AT 81° REF. BRIX (CALCULATED) – ASH % NON-SUCROSE

FINAL MOLASSES—FACTORY A



in Total Sugars on 100 parts water can be accounted for by variation in per cent. Moisture. The standard deviations of the regression coefficients are also very small.

An examination of the correlation diagrams shown in Figs. 1, 2, and 3 reveals that, while Factory A has a higher ash content in final molasses than Factory B, the regression lines differ very little, both in their relative positions on the diagrams and also in their angles of slope. The fact that their relative positions are about the same, suggests that the net effects of factors other than per cent. moisture on Total Sugars on 100 parts water are also approximately the same in both cases.

Both "Total Sugars on 100 parts water" correlation coefficients are significantly higher than the corresponding "Sucrose on 100 parts water" correlation coefficient (Factory A, $Z=0.52\pm0.18$; Factory B, $Z=1.39\pm0.42$). It is therefore safe to assume that "Total sugars on 100 parts water" is a more reliable Exhaustion Measure than "Sucrose on 100 parts water." This result suggests that an important part may be played by reducing sugars in determining the degree to which a molasses may be exhausted. Since the 1931 Factory A series of samples were still available in a fresh condition, an attempt was made to determine whether the reducing sugars present were composed of approximately equal or widely varying proportion of fructose and of glucose. The necessary data was therefore collected, and it was shown that the proportion of the two hexoses varied over a fairly wide range. No relationship could, however, be found to exist between the small variations from the regression line of "Total Sugars on 100 parts water" and these varying proportions of hexose sugars. It is possible therefore that, as far as could be determined and under the conditions of this investigation, there is very little difference between the effect of glucose and of fructose on the solubility of sucrose.

Table 6.

Fine Grain Estimations.

$$\text{Per cent. Fine Grain} = \frac{100\,(p - q)}{100 - q}$$

(10 per cent. by wt. of water added, therefore factor = 1.10)

FACTORY A.—CROP 1931.

Optical Brix.		p × 1.10	Per cent. fine grain.
Original (q).	After Dilution and stirring (p).		
82.2	75.2	82.7	2.8
81.3	74.6	82.1	4.3
82.2	74.9	82.4	1.1
82.9	76.0	83.6	4.1
81.0	74.2	81.6	3.2
81.9	74.6	82.06	.9
82.2	74.9	82.4	1.1
80.6	74.1	81.5	4.6
81.6	74.5	81.9	1.6
81.8	74.8	82.3	1.6
82.8	75.4	82.9	.5

The effect of the presence of fine grain on the correlation coefficient was next determined. The Refractometer method described by Kalshoven (12) was employed, and proved to yield accurate and reproducible results. These are presented in Table 6. Again using Kalshoven's procedure, the sucrose per cent. on a grain-free basis was calculated with the results shown in Table 7. With this data, it was possible to calculate the "Total Sugars on 100 parts Water and per cent. Moisture" correlation coefficient for the 1931 series on a grain-free basis.

The coefficient so determined was—0.96, which is higher than that obtained from the pooled data on a "total sucrose basis". This result was to be expected since the use of "grain-free sucrose" data tends to even out any small fluctuations in boiling-house efficiency.

The amount left from any of the samples was not sufficient to determine Sucrose per cent. at 81° Ref. Brix, as suggested by Thieme, by attaining equilibrium at that concentration. It was therefore not possible actually to estimate the value of either Ash per cent. Non-sucrose as an Exhaustion Factor or Sucrose per cent. at 81° Ref. Brix. as an Exhaustion Measure on the samples available. However, the sucrose per cent. in all the samples of Factory A were calculated to a basis of 81° Ref. Brix. although it was realized that in so doing, the effects of concentration, &c., are totally ignored. This calculated data was then correlated with Ash per cent. Non-Sucrose and the results are summarised in Table 8.

Table 7.

FACTORY A.—CROP 1931.

Total Sucrose Per cent. (s).	Grain – Free Sucrose Per cent.	True Optical Purity.	
		Original.	Grain-Free.
33.67	31.75	40.96	38.63
33.89	30.95	41.68	38.06
34.33	33.60	41.76	40.88
34.93	32.16	42.13	38.80
34.20	33.87	42.22	41.82
34.88	34.30	42.58	41.88
33.85	32.73	41.18	39.82
31.80	28.48	39.45	35.34
34.13	33.03	41.82	40.48
33.59	31.70	40.81	38.75
35.34	34.61	43.27	42.11

The corresponding correlation diagram is shown in Fig. 4.

The value of the correlation coefficient is reduced by comparison with Thieme's results set out in Table 1. (Correlation 3 (*a*)). This result is probably due to the present data tending to accumulate towards the lower end of the regression line, whereas Thieme's data is spread

Table 8.

FACTORY A.—DATA.

	No. Pairs.	Correlation Coeff.	Regression Coeff.	X=
Per cent. Sucrose at 81° Ref. Brix (Calculated) (X) and Ash Per cent. Non-Sucrose (Y).	64	+0.56	0.331±0.103	25.86+0.331 y

Table 9.

Thieme's Data (calculated).

	No. Pairs.	Correlation Coeff.	Regression Coeff.	X=
Per cent. Sucrose at 81° Ref. Brix (Calculated) (X)—Ash Per cent. Non-sucrose (Y)	19	+0.87	+.579±0.12	17.58+0.579 y

more or less evenly along it. While the two regression coefficients differ in value, the relative magnitude of their standard deviation is about the same, *i.e.*, "t" is approximately 3.0 in both cases. In attempting to estimate the practical utility (*a*) of a correlation, the most important factor to be considered is not so much the value of the correlation coefficient, but the ratio of the regression coefficient to its standard deviation, since it is from this figure that the unknown variant is calculated from the known. If this ratio is too low, the result of the calculation will be nothing more or less than an approximate estimate, but if the ratio is high, then the reliability becomes very much greater.

From this point of view the calculated data give as significant a regression coefficient as the experimental data of Thieme. This is also true when Thieme's analyses are used and the per cent. Sucrose at 81° Ref. Brix is calculated from the original concentrations of the various samples. These results, when correlated with Ash per cent. Non-sucrose, are set out in Table 9.

It will be noticed that the value of "t" for the regression coefficient has increased $\frac{(0.579}{0.12}=4.8$, as against approximately 3.0) but it is still of a relatively low order.

Table 10 presents a comparison of these calculated per cent. Sucrose figures with the ones obtained by Thieme experimentally.

(*a*) The term "practical utility" is used to express the degree of accuracy which would be obtained in practice if, for example, the Ash Per cent. Non-Sucrose of a random sample of molasses was known, and it was desired to calculate the value of the sucrose per cent. at 81° Ref. Brix after that molasses had been totally exhausted.

Table 10.

Thieme's Data.

Sample No.	Per cent. Sucrose (by Saturation at 81° Ref. Brix). (Copied from Thieme's table.)	Per cent. Sucrose (by calculation from original conc. to 81° Ref. Bx.) (Calculated from Thieme's Anal.)
1	32.4	26.8
2	32.4	27.6
3	31.5	26.9
4	32.8	25.9
5	35.0	28.4
6	31.8	28.0
7	32.1	29.3
8	30.8	29.9
9	30.2	27.2
10	36.9	31.7
11	37.3	34.6
12	36.5	33.2
13	39.5	37.2
14	31.2	32.7
15	35.4	32.4
16	32.4	29.7
22	35.2	34.7
23	33.7	37.1
24	33.2	29.7
Mean	33.7	30.2

These means are significantly different, as shown by the summarised data set out in Table 11.

From this it may be concluded that, while the calculated data yield as significant a regression coefficient as the experimental data, the former are of but little use in controlling the exhaustion of molasses, because the result obtained from the regression equation would be significantly different from the true one.

Table 11.

Test of Significance of Difference of Means of Per cent. Sucrose.—Thieme's Data.

	Mean.	D.F.	S.D.	Variance.	S.D. of Difference.	t=
Experimental	33.7	18	±2.46	6.08	±0.84	4.1
Calculated	30.2	18	±2.85	8.15		

V.—Discussion.

The following illustrates the reason why the importance of the magnitude of the standard deviation of the regression co-efficient has been emphasized in presenting the above statistical results:

Assume that it is desired to use the correlation set out in Table 1 (3 (*a*)) for example, and calculate the value of the Sucrose per cent. at 81° Ref. Brix when the Ash per cent. Non-sucrose is 21.8. The regression equation is $X=22.49+0.467\ y$ and the standard deviation of the regression coefficient is ±0.14. Firstly, calculate the value for X (Sucrose per cent. at 81° Ref. Brix) when the standard deviation is negative. The value so obtained is 29.61. Secondly, calculate the value for X when the standard deviation is positive. The value is found to be 35.72. According to this data, therefore, the chances are against a molasses with an Ash per cent. Non-sucrose of 21.8 not being exhausted when the value for per cent. Sucrose at 81° Ref. Brix lies between 29.61 and 35.72. The difference of 6.11 is appreciable and illustrates very clearly why a correlation to be used to measure molasses exhaustion must be judged not so much on the significance of the correlation coefficient, but on the magnitude of standard deviation of the regression coefficient.

The suggested use of the correlation, "Total Sugars on 100 parts water and per cent. Moisture" is put forward because: (1) The regression coefficient is highly significant, *i.e.*, the standard deviation is extremely low, (2) The analyses required may be rapidly carried out by means of routine procedures, and (3) although it is based, in part, on a factor (reducing sugars) which is liable to vary in composition, such variation does not apparently effect the result to any appreciable extent.

The use of Exhaustion Factors such as "Glucose—Ash Ratio" and "Ash per cent. Non-sucrose" is criticised, firstly, because the determination of ash is a fairly long procedure and, secondly, because, as a factor effecting exhaustion of molasses and to be used in all sugar-growing countries, the ash is liable to extremely wide variation in composition. It has not yet been possible to show that a unit weight of typical Java ash, for example, has the same effect on the solubility of sucrose as a unit weight of typical Demerara ash.

The correlation suggested in this investigation is based on data which shows that the ash per cent. final molasses does not vary to any appreciable extent within the same factory, and hence ash as a variant may, under these conditions, be eliminated. It is an extremely useful guide as to the relative value of two boiling house processes or as a check on the boiling house work from one week to the next, but it is not possible to use the correlation to compare the efficiency of one factory with that of another, and this is in some respects a disadvantage. The work entailed in establishing the regression equation is not very great since the data could, in all probability, be obtained from daily analyses sheets of past crops. The analyses of twenty samples spread over, say, two crops should give a significant regression coefficient. If, however, these are not available, a start may be made by obtaining the analyses of molasses from several consecutive crystallizers and the statistical data recalculated when the analyses of several weekly composite samples have accumulated.

VI.—Summary.

1. Weekly composite samples of final molasses have been collected for the past four crops and analysed.

2. It has been shown that the ash per cent. in any one factory does not vary significantly from one crop to the next.

3. A correlation has been suggested for use as a measure of the exhaustion of molasses. (Total Sugars on 100 parts water and per cent. Moisture.)

4. This correlation has a highly significant regression coefficient.

5. "Sucrose at 81° Ref. Brix" as an Exhaustion Measure is criticised on the grounds that the determination is carried out by a time consuming process in the laboratory. It has been shown that this value cannot be calculated from other concentrations.

6. "Ash per cent. Non-sucrose" and "Glucose—Ash ratio" as Exhaustion Factors are criticised chiefly on the grounds that wide variations are known to occur in the composition of ash from molasses obtained in different countries.

7. It has been pointed out that the value of any correlation to be used to measure molasses exhaustion must be judged not on the significance of the correlation coefficient, but on the ratio of the regression coefficient to its standard deviation.

8. The suggested correlation can be used to judge the work of one factory but not as a basis of comparison between two or more factories.

9. The necessary statistical calculations are set out in the Appendix.

VII. Bibliography.

1. Geerligs. *Sugar-Cane* (1893), Vol. XXV, p. 284; (1896) Vol. XXVIII, p. 311.
2. Van der Linden. *Archief* (1919) I, 501.
3. Van der Linden. *Archief* (1919) I, 1511.
4. Van der Linden. *Archief* (1915) II, 1033, 1389.
5. Sylmans. *Archief* (1924) III, 413.
6. Thieme. *Archief* (1930) II, 1155. *Abs. I.S.J.* (1931) 33. 244.
7. Thieme. *Archief* (1931) 361. *Abs. I.S.J.* (1931) 33. 408.
8. McDonald *Memoirs I.C.T.A.* (*Sug. Tech. Series*) No. 2.
9. Lebedeff. *Vereinzeitschaft* (1908) 606.
10. Lippman. *Chernie der Zuckerarten* (1904) 1098.
11. Fisher. *Statistical Methods for Research Workers.* Table V. (*a*).
12. Kalshoven. *Archief* (1920) 937.

VIII.—Acknowledgments.

The author wishes to express his deep appreciation of the co-operation afforded by the staffs of the sugar factories of Trinidad, especially by the staff of Factory A, in the collection and forwarding of composite weekly samples of final molasses, and to his colleague Mr. P. E. Turner, for his helpful advice and constructive criticism of the statistical part of this article.

IX.—Appendix.

1. Correlation Coefficient.

In the calculation of the correlation coefficient, the data are set out in pairs as shown below. For any one value X, the corresponding value of Y must be placed on the same line, so that the "xy" column shows the product of the moments of any pair from their respective means. "x" or "y" is the deviation of any one value of X or Y from its mean. The totals of the deviation squared (x^2 and y^2) columns are then obtained, together with the algebraic total of the columns "+xy" and "−xy". The correlation coefficient is calculated as shown.

Factory B.

Total Sugars on 100 water. *Per cent. Moisture.*

X	x	x^2	Y	y	y^2	xy +	xy −
364	+68	4624	16.4	−2.7	7.29		183.6
318	+22	484	18.0	−1.1	1.21		24.2
295	− 1	1	19.1	0	0		0
286	−10	100	19.7	+0.6	.36		6.0
313	+17	289	18.0	−1.1	1.21		18.7
309	+13	169	18.3	−0.8	.64		10.4
314	+18	324	18.0	−1.1	1.21		19.8
286	−10	100	19.6	+0.5	.25		5.0
254	−42	1764	20.8	+1.7	2.89		71.4
280	−16	256	19.9	+0.8	.64		12.8
260	−36	1296	20.9	+1.8	3.24		64.8
282	−14	196	19.8	+0.7	.49		9.8
281	−15	225	19.8	+0.7	.49		10.5
365	+ 9	81	18.6	−0.5	.25		4.5
						0	−441.5
Mean Value of X =296 ($\bar{x}$)		$\Sigma x^2 = 9909$	Mean Value of Y=19.6 ($\bar{y}$)		$\Sigma y^2 = 20.17$	$\Sigma xy = -441.5$	

$$\text{Correlation Coefficient } (r) = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \times \Sigma y^2}}$$

$$= \frac{-441.5}{\sqrt{199864.53}}$$

$$= \frac{-441.5}{447.0}$$

$$= -0.98$$

2. Regression Coefficient and Regression Equation (1).

The calculation of the regression coefficient may now be proceeded with on the following lines :—

$$\text{Regression Coefficient of X on Y} = b_X \overset{(a)}{=} \frac{\Sigma xy}{\Sigma y^2}$$

$$b_X = \frac{-441.5}{20.17}$$

$$b_X = -21.89$$

To obtain the standard deviation of this coefficient, an analysis of the variation in X is necessary and is carried out as follows :-

Total Variation in X $= \Sigma x^2 = 9909$

Variation due to Y $= (b_X) \times (\Sigma xy) = (-21.89) \times (-441.5)$
$= 9664$

Error = Difference of these two $= 235$

$$\text{Standard Deviation}^2 \text{ of regression coeff.} = S^2 = \frac{\text{Error.}}{\left(\begin{matrix}\text{Total}\\ \text{Variation}\\ \text{in x}\end{matrix}\right) \times \left(\begin{matrix}\text{Degrees}\\ \text{of}\ (b)\\ \text{Freedom.}\end{matrix}\right)}$$

$$= \frac{235}{9909 \times 12}$$

$$= \frac{235}{118908}$$

$$= .001977$$

$$S = \sqrt{.001977} = .044$$

$\therefore$ Regression Coefficient $= -21.89 \pm .044$

The regression equation enables the value of X to be calculated from the corresponding value of Y. The method of procedure is as follows :—

Prediction of X from Y.

(Required value of X) − (Mean value of X) = (Regression coefficient of X on Y) $\left[\begin{matrix}(-\text{mean value of Y})+\\ (\text{observed value of y})\end{matrix}\right]$

or written statistically :—

$$X - \bar{x} = b_{\bar{x}} (-y + y_1)$$
$$X - 296 = 21.89\ (-19.1 + y_1)$$
$$X = 296 + 418 - 21.89\ y_1$$
$$= 714 - 21.89\ y_1$$

Suppose the observed value of y (shown as y_1 in equation) is found to be 16.0 (that is the per cent. Moisture in a sample of molasses), what should be the total sugars on 100 parts water if the efficiency of the factory is being maintained?

$$X = 714 - 21.89\ y_1$$
$$= 714 - (21.89 \times 16.0)$$
$$= 714 - 350$$
$$= 364 = \text{Value of total sugars on 100 parts of water when moisture per cent. molasses} = 16.0$$

and the efficiency of the boiling house is being maintained.

Factory superintendents not experienced in the use of statistics will no doubt conclude that the procedure laid out above is to some extent complicated. Let them be assured however, that provided the operations detailed in the example are carefully followed and the values obtained from their own data substituted for those employed in the example, the actual calculations then involve nothing more than a knowledge of simple arithmetic.

(*a*) Determination of change in the value of X for each unit change in the value of Y.

(*b*) Degrees of Freedom equals, in correlations such as this, number of samples less two. *i.e.*, 14−2=12.

(1) Turner, P. E.—*Jour. Agri. Sci.* (1932) "An Analysis of Factors contributing to the Determination of Saturation Capacity of Tropical Soil types".

CULTIVATION EXPERIMENTS WITH SUGAR-CANE.

I.—THE EFFECT OF TYPE OF PREPARATORY TILLAGE ON YIELD OF PLANT CANES.

By

P. E. TURNER,

(*Soil Chemist to Sugar-Cane Investigation Committee*).

[*The following paper was read at the meeting of the International Congress of Sugar-Cane Technologists held at Porto Rico in March,* 1932.]

I.—Introduction.

In a recent paper Nicoll (6) has classified and summarised the methods which have been adopted in the Hawaiian Islands for the preparation of the soil previous to planting of sugar-cane. He draws the conclusion that the general attitude towards this most important field operation has been one of satisfaction in past systems, coupled with occasional alterations based on personal opinion and preference. He emphasises the diversity of the methods in use and shows that a very definite need exists for a comparison of their relative values by a well-defined series of experiments.

Past experience has shown that it is difficult to carry through experiments of this type to a satisfactory conclusion, in that the differences resulting from the various treatments, under circumstances which appear promising, are rarely found to be significant or even consistent.* This lack of success is due in part to the difficulties inherent to experiments of this class, which are much greater than those normally encountered in manurial trials. It may also to some extent be explained by the fact that the experiments have not always been designed in a manner likely to lead to conclusive results. In this respect, neglect of plot randomisation has been an important contributory factor.

In a sugar-cane area such as Trinidad, which varies not only in topography, but which also includes a wide range of mechanically differing soil types, further difficulties arise. It is then essential that the experiments should be performed on estates (plantations), rather than within the grounds of an experiment station, in order that the information derived should be directly applicable to local conditions. As most sugar-estates possess limited facilities for accurate experimental work of such nature, it becomes a matter of difficulty to plan schemes which can be brought to a successful conclusion and also yield data capable of statistical analysis on modern lines.

* The lack of consistency which frequently obtains in cultural experiments is well illustrated by a series of trials laid down in Mauritius in 1923 (8). The yields from three fields, each divided into two sections, one of which was ploughed and holed previous to planting and the other merely holed, are as follows :—

Yields per acre in long tons.

Field Number	(1)	(2)	(3)
Unploughed Section	27.0	42.4	30.4
Ploughed Section	37.9	38.7	31.7
Difference in favour of ploughing	+10.9	− 3.4	+ 1.3

In Trinidad it has been found possible to perform certain tillage experiments on estates with success.

II.—Aims of the Tillage Experiments.

In the experiments outlined below there are compared the effects on yield of sugar-cane per acre of two distinct types of tillage treatment which are customarily used in the preparation of land before planting. As the treatments are few in number the experiments are simple in character, but their design is of a nature which readily lends itself to the inclusion of a relatively large variety of treatments.

It should be noted that the experiments described were laid down mainly to provide preliminary information, previous to the initiation of more complex experiments of a similar type. The data obtained for the plant canes are published somewhat prematurely in the hope that they may be of guidance to other workers. The corresponding data for the ratoon canes will be published in due course.

Detailed Aims.

(1) To test the possibilities, for cultivation experiments with sugar-cane, of a certain design of randomised layout, with especial reference to:—

(*a*) its suitability to research of this nature in general, and its practicability under estate conditions in particular.

(*b*) the order of magnitude which differences in yield must possess to be statistically significant.

(*c*) the number of replicates of each treatment which are required for the significant difference to lie within prescribed limits.

(2) To compare the yields of sugar-cane resulting from mechanical tillage preparatory to planting, with those consequent upon hand-forking.

In Experiment I the effect of tractor-ploughing is compared with that of hand-forking. In Experiment II chiselling (knifing) is compared with hand-forking.

(3) To obtain a preliminary estimate of the financial gain, if any, derived from mechanical tillage in comparison with hand working.

The choice of the particular treatments recorded under the second aim was determined by the steady increase in yield of sugar-cane to the acre in Trinidad since the use of mechanical tillage became general. Before 1924, with the exception of one or two estates, hand-forking was the

Block I					Block II					Block III					Block IV				
P_4	P_2	P_1	F	P_3	P_3	P_4	P_1	F	P_2	P_1	F	P_4	P_2	P_3	P_1	F	P_2	P_3	P_4

Fig. I.

method in most common use of preparing the land previous to planting. From 1924, onwards, mechanical methods have found increasing favour, and are now employed on all the large estates. The part played by these methods in increasing yield in Trinidad has hitherto been doubtful, for it has to some extent coincided with an extended use of manures. The tillage experiments were intended to give information in this respect.

III.—Details of Tillage Experiments.

EXPERIMENT I.—TRACTOR PLOUGHING *versus* HAND-FORKING.

Cane Variety.—Uba.

Soil Type.

An old river alluvium. This soil type has been described elsewhere (9), (10).

Layout.

Four randomised blocks with five strips (or plots) in each block (Fig. I). Each strip consists of one bed. The beds are separated by drains two feet wide and one foot deep.

Dimensions of each strip = 22 feet × 198 feet (1/10 acre).

System of Randomisation.

One strip at random in each block is hand-forked (F). The four remaining strips are ploughed (P_1, P_2, P_3 and P_4). All the ploughed strips received identical treatments. They are numbered at random to facilitate analysis of the yield data.

Details of Tillage Treatments.

F plots.—Furrowed with hand-fork to a depth of six inches, with sub-soiling of the furrow (October, 1929). The area between the furrows was hand-forked after the banks were broken (January, 1930).

P plots.—Tractor-ploughed, to a depth of 12 inches, with a 28-inch, 4-furrow, disc plough (March, 1929). The plots were subsequently furrowed by hand (October, 1929), but not subsoiled. They were not forked after the breaking of banks (January, 1930).

Both sets of plots were round ridged by hand (October, 1929).

Dates of Planting and Reaping.—(F and P plots).

Planting .. ..October, 1929.
Reaping (after burning) ..March, 1931.
Age of Plant Canes on reaping ..17 months.

Manurial Treatment (F and P plots).

Fifteen tons of pen manure to the acre at the time the banks were broken (January, 1930).

Previous History of the Experimental Area.

The area was previously planted in Uba canes, which were ratooned at least nine times. It had received little or no cultivation for at least nine years.

Although ground limestone was applied to the area at the rate of 2½ tons to the acre as long ago as 1919, evidence still exists of its presence, unchanged, in the soil. It has been shown that lime acts very slowly on this type of soil (9).

EXPERIMENT II.—CHISELLING (KNIFING) *versus* HAND-FORKING.

Cane Variety.—P.O.J. 234.

Soil Type.—River alluvium.

This soil type has been previously described (5), (10).

Layout.

Three randomised blocks with six strips (or beds) in each block (Fig. II).

Dimensions of each strip = 660 feet × 22 feet (1/3 acre).

System of Randomisation.

One strip at random in each block is hand-forked (F). The five remaining strips (C_1, C_2, C_3, C_4 and C_5), which receive identical treatments, are chiselled.

Details of Tillage Treatments.

F plots.—As in Experiment I, except that these plots were forked to a depth of *eight inches* instead of six inches.

Block I						Block II						Block III					
C_4	C_1	C_2	C_5	C_3	F	C_5	C_4	C_1	F	C_2	C_3	C_2	C_3	F	C_4	C_5	C_1

Fig. II.

C plots.—Tilled with a heavy duty chisel, or knifer, drawn by a tractor (March, 1930). The chisel has three knives, each two feet three inches apart. It returns between its tracks, the cuts thus being one foot one and a half inches apart. When used in the dry season this instrument completely shatters the soil to a depth of 12 inches, giving it a loose tilth.

Dates of Planting and Reaping.

Planting .. ..March, 1930.
Reaped * (after burning) ..March, 1931.
Age of Plant Canes on reaping ..12 months.

Manurial Treatment (F and C plots).

10 tons of filter press mud per acre in March, 1930.

3 cwt. of ammonium sulphate per acre in May, 1930.

Previous History of the Experimental Area.

The area was chiselled for the first time in 1930. In previous years it was cattle-ploughed before planting.

IV.—Analysis of Yield Data.

EXPERIMENT I.

Table I.—Actual Yields † of Plant Canes per Plot in cwt. (of 112 lb.), less 70 cwt.

Block.	Treatment.					Total.
	P_1	P_2	P_3	P_4	F	
I	3.25	2.75	− 4.00	−0.50	−18.50	−17.00
II	1.00	−3.00	−11.00	−4.00	−22.75	−39.75
III	−5.00	6.75	5.50	9.75	− 7.00	10.00
IV	3.50	10.75	6.25	9.00	−10.50	19.00
Total	2.75	17.25	− 3.25	14.25	−58.75	−27.75
	31.00					

General Mean = −1.3875

Table II.—Analysis of Variance. ‡

Due to.	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (Mean Square).
Blocks	3	427.509	142.503	
Treatments	1	884.450	884.450	2.2412
Error { Interactions between Blocks and Treatments	3 } 15	293.725	19.581	0.3360
Error { Between parallel plots	12 }			
Total	19	1605.684	—	—

Standard Error of a single plot = $\sqrt{19.581}$

Standard Error (*mean of four plots*) = $\sqrt{19.581 \div 4}$ = 2.21 or 3.23 per cent. of the mean yield of (70−1.3875), or 68.61 cwts.

Results of Analysis.

The difference in yield due to treatment is certainly significant in this experiment. For $n_1 = 1$ and $n_2 = 15$, the one per cent. point in Fisher's table of z (3) is 1.0807. The difference due to treatment in Table II is 2.2412−0.3360, or 1.9052. A difference of this amount might occur by chance far less than once in 100 trials.

Final Analysis.

Table III.—Mean Yields of Plant Canes per acre.

(cwts. of 112 lb.)

Tractor-Ploughed plots.	Hand-Forked plots.	Difference.	Standard Error of Difference.
719.4	553.1	166.3	31.3

* The canes caught fire by accident and were reaped prematurely.

† In both experiments the canes were weighed to the nearest quarter (28 lb.)

‡ For an explanation of the method of analysis see references (4) and (12).

For P=0.05, t=2.131 when n=15 (3). A difference to be significant must therefore exceed 2.131 × 31.3=66.7 cwts. This difference is equal to 9.72 per cent. of the mean yield.

For P=0.01, t=2.947 when n=15. The significant difference then equals 2.947×31.3=92.2 cwts.

The difference in yield of 166 *cwts. per acre, when tractor-ploughing is compared with hand-forking, is undoubtedly significant.*

EXPERIMENT II.

Table IV.—Actual Yields of Plant Canes per Plot in cwts. (of 112 lb.), less 135 cwts.

Block.	Treatment.						Total.
	C_1	C_2	C_3	C_4	C_5	F	
I	4.50	2.75	10.25	3.50	11.00	−15.50	16.50
II	7.50	9.50	9.75	12.75	13.00	− 5.25	47.25
III	1.25	−3.25	12.75	19.75	39.00	− 2.25	67.25
Total	13.25	9.00	32.75	36.00	63.00	−23.00	131.00
	154.00						

General Mean=7.278

Table V.—Analysis of Variance.

Due to	D.F.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (Mean Square).
Blocks	2	217.840	108.920	
Trea ments	1	804.011	804.011	1.0422
Error { Interactions between Blocks and Treatments	2 } 14	1222.635	87.331	$\bar{1}$.9323
Error { Between parallel plots	12 } 14			
Total	17	2244.486	—	—

Standard Error of a Singl· Plot = $\sqrt{87.331}$

Standard Error (*mean of three plots*) = $\sqrt{87.331 \div 3}$ = 5.395, or 3.79 per cent. of the mean yield of (135+7.278), or 142.28 cwt.

Results of Analysis.

Treatment difference is again significant in this experiment. For $n_1=1$ and $n_2=14$, the one per cent. point in the table of z (3) is 1.0909. The difference due to treatment in Table V is 1.0422−$\bar{1}$.9323, or 1.1099. A difference of this amount might occur by chance about once in 100 trials.

Final Analysis.

Table VI.—Mean Yields of Plant Canes per acre.
(cwt. of 112 lb.)

Chiselled plots.	Hand-Forked plots.	Difference.	Standard Error of Difference.
435.9	381.9	54.0	22.9

For P=0.05, t=2.145 when n=14 (3). The difference, to be significant, must exceed 2.145 × 22.9=49.1 cwt. This difference is equal to 11.50 per cent. of the mean yield.

The difference in yield of 54 *cwt., when chiselling is compared with hand-forking, is significant.*

V.—Discussion and Conclusions.

(1) DESIGN OF THE CULTIVATION EXPERIMENTS.

(*a*)—(i) *Design of Layout.*

Randomised blocks, situated side by side in the field, appear to constitute an eminently satisfactory type of layout for the purpose of cultivation experiments, for no practical difficulties were experienced in the initiation of either of the trials.

In both experiments all the plots tilled with mechanical aid received identical treatment. Such replication of plots within blocks is not essential

as a rule. In cases in which the effects of a number of types of cultivation are to be compared, each plot in a block would normally receive a different treatment, unless special circumstances render desirable repetition of one or more treatments. Resort is frequently made to replication of this nature when the number of treatments is very small, but it is then usually advisable to equalise as far as possible the number of replicates in each block. In the tillage experiments described, for example, the mean yield of the mechanically cultivated plots is based on the yields of 15 or 16 replicates, whereas that of the hand-forked plots is based on the yields of only three or four replicates. It is possible that a more reliable estimate of the difference due to treatment would have been obtained if the number of hand-forked plots to the block had been increased, even though this necessitated a reduction in the number of mechanically tilled plots.

(*ii*) *Plot Size and Shape.*

In both experiments the plots are of large area. They consist of long and narrow strips, which run the whole length of the field and which, under Trinidad conditions, conveniently correspond to the permanent cane beds. This shape of plot appears ideally adapted to cultivation experiments, in that it gives implements propelled by steam or Diesel tackle, or by tractors, an ample length of run. Care should be taken, however, to ensure that the beds are of equal width and length throughout the field.

In Experiment I only 1/10 acre within each plot was harvested, the ends of each plot, where edge effect was apparent and where tillage treatment was not invariably typical, being excluded and separately reaped. In Experiment II each strip (1/3 acre in area) was reaped as a whole. The standard error of a single plot, expressed as a percentage of the mean yield, is 6.45 in the former case. In the latter it is 6.57. Little therefore appears to have been gained by the limitation of plot area in Experiment I. As an offset to the disadvantages which the large plots in Experiment II may possess, it is probable that errors in weighing are very small in comparison with plot yield. This is a very important factor under normal estate conditions.

Since the initiation of the tillage trials Christidis (1) has pointed out that significant results cannot be secured in agricultural experiments merely by using the appropriate statistical methods, and that uniformity among the individual plots is an essential qualification. He has shown that the shape of the plots constitutes an important means of controlling soil heterogeneity, and that its effects may be reduced by making the plots as long and as narrow as possible, within certain limits. Plots of the shape used can therefore be justified both on theoretical and on practical grounds. It is of interest to note that Experiment II was not invalidated by the use of plots with a ratio of length to width as great as 30 to 1 (660 feet by 22 feet).

Data concerning manurial experiments, in which long and narrow plots are used, are given by the author elsewhere (11).

(*b*) *Magnitude of the Significant Difference.*

In Experiment I the standard error, *based on the mean for four plots*, is 3.23 per cent. of the mean yield. In Experiment II, *for the mean of three plots*, it is 3.79 per cent. of the mean yield. The figures compare favourably with the corresponding percentages, for cultivation experiments, published in the Rothamsted Reports (7).

In both tillage experiments, however, the significant difference possesses a value roughly equal to ten per cent. of the mean yield. Differences of this magnitude are not likely commonly to occur in cultivation trials unless the treatments vary greatly in efficacy. Consequently, in order generally to secure conclusive results, from experiments with a simple layout, it appears necessary to replicate each treatment considerably more than four times.

(*c*) *Number of Replicates for a Prescribed Significant Difference.*

An estimate of the number of plots receiving identical treatment, which are required for the significant difference to possess a given value, may be obtained as follows :—

Let the standard error of a single plot be $\sqrt{x}$.

Then the standard error of the mean of y plots $= \sqrt{x/y}$. Taking the significant difference to be three times the standard error, significant difference $= 3\sqrt{x/y}$.

Substituting the value found in Experiment I for the standard error of a single plot, and assuming the prescribed significant difference to be five per cent. of the mean yield (*i.e.* 3.43 cwt. per plot, or 1.715 tons per acre),

$$3.43 = 3\sqrt{(19.581)/y}.$$

Whence $y = 15$.

The corresponding value of y is 16 in Experiment II, for a significant difference of five per cent. (in this case 21.33 cwts. per acre).

Under these circumstances, therefore, as many as 15 or 16 randomised blocks are required if the treatments are not replicated within the blocks. The blocks need not all be congregated in one field. They may be detached and placed in different fields.

(2) Mechanical Tillage *versus* Hand-Forking.

Experiment I.—The difference in yield of 8 tons 6 cwts. to the acre in favour of tractor-ploughing, when compared with hand-forking, is surprisingly large.* The difference may be ascribed to two main causes :—

(1) The difference in depth to which the soil was worked.

* A difference of 10 tons 18 cwts. was obtained *in one field* in the cultural experiment in Mauritius (page 1, footnote), under somewhat similar circumstances.

The mechanically tilled plots were ploughed to a depth of 12 inches, whereas the hand-treated plots were forked only to six inches.

(2) The difference in time at which the soil was worked.

The mechanically tilled plots were ploughed relatively early in the dry season, and the overturned clods exposed to the action of sun and rain for seven months before planting. The soil of the experimental area sets too hard in the dry season for forking to be practicable. Hand work has therefore to be delayed until the advent of the wet weather, when planting operations should be in full force.

Experiment II.—In this experiment the difference in yield due to treatment is much smaller than in Experiment I. This appears to be due to a variety of causes, which include :—

(1) Effect of variety of cane. In Trinidad P.O.J. 234 does not give as heavy yields as Uba.

(2) Effect of season of planting and age of cane. The P.O.J. canes were planted under dry season conditions and reaped when 12 months old. The Uba canes were planted in the wet season and harvested when 17 months old.

(3) Effect of difference in soil type.

(4) Effect of type of mechanical tillage, and depth of hand-forking.

(5) Effect of type of manurial treatment.

The results given by Experiments I and II are of interest when compared with those obtained in Java, where greater yields are given by the Reynoso system of tillage, in which the soil is hand-worked, than by ploughing (2).

(3) Costings.

For the year 1931, on the estate on which Experiment I was laid down, the average cost of tractor-ploughing, including depreciation and the usual other charges, was $7.44 per acre. For the five years 1926-30, on this estate, the average cost of preparatory hand-forking to a depth of six inches was $6.02 per acre. The substitution of mechanical tillage for hand-forking has therefore resulted in an increment in yield to the acre of 8 tons 6 cwts. of cane at the very small extra cost of $1.42.

During 1931, on the estate on which Experiment II was laid down, the cost of chiselling lay between $7 and $8. The average cost of hand-forking to a depth of eight inches on this estate is $8 per acre. The increment in yield of 2 tons 14 cwts. of cane to the acre at the worst was obtained without increasing the expenditure.

On both estates the introduction of mechanical tillage has lessened the cost of subsequent cultivation operations, such as the making of banks previous to planting, and forking to remove weeds after planting. The financial gain is therefore definitely greater than the data recorded above suggest. In addition, the comparison of costs is made on the basis of the yield of canes only as plants. The effect of type of tillage is very likely to be evident in the yield of ratoon canes, especially in the case of Experiment I. To increase the accuracy of the balance sheet, and to obtain information with regard to the relative residual effect on yield of the two methods of preparatory tillage, the plots in both experiments are to be reaped again in 1932 (first ratoons) and 1933 (second ratoons).

Other important points arise in favour of mechanical tillage in Trinidad. The area which can be replanted in any one year is limited mainly by two factors, time and supply of suitable labour. The replacement of hand-working by mechanical tillage not only enables a much larger area to be prepared, and apparently more efficiently prepared, per unit of labour, but the work can be completed before the wet season sets in. On the other hand, preparatory forking is usually not possible until the advent of the rains, because of the manner in which the soil cements in dry weather. As the labour is largely engaged in rice planting early in the wet season, there may be even further delay before cultivation operations are in full swing on sugar estates. Mechanical cultivation therefore allows earlier planting and a longer growing season for the crop. Further, it renders more labour available for subsequent operations, such as the making of banks, and as these operations require less energy after mechanical ploughing than hand-forking, an adequate supply of labour can more readily be obtained.

VI.—Summary.

The need which exists for cultivation experiments on sugar-cane, and the difficulties encountered in bringing experiments of this type to a satisfactory conclusion under estate conditions, are briefly discussed.

The design and layout of two tillage trials of a preliminary character, which have been successfully carried out in Trinidad, are described.

The aims of the experiments are :—

(*i*) To test the possibilities of a certain type of randomised layout, with especial reference to (*a*) its practical suitability ; (*b*) the order of magnitude which differences in yield, resulting from varying treatment, must possess to be statistically significant ; and (*c*) the number of replicates of each treatment which is required for the significant difference to lie within prescribed limits.

(*ii*) To compare the effect on yield of plant canes of tractor-ploughing and of chiselling with that of hand-forking.

It is shown that :—

(1) The yield of plant canes from the tractor-ploughed and chiselled plots exceed those from the hand-forked plots by 166 cwt., and 54 cwt., per acre, respectively. In both comparisons the difference is definitely statistically significant.

(2) Randomised blocks, situated side by side in the field, constitute a suitable and practicable type of layout for cultivation experiments.

(3) Satisfactory results may be obtained by the use of long and narrow plots, which under Trinidad conditions correspond to the permanent cane beds,

and which run the whole length of the field. The plots may have a ratio of length to width of 30 to 1, and may be as large as 1/3 acre in area.

(4) In the experiments described the significant difference in yield, based on the mean yield for three or four plots, possess a value roughly equal to ten per cent. of the mean yield.

A method is given of estimating the number of replicates of each treatment which are necessary for the difference to possess a prescribed value.

(5) A preliminary estimate is made of the immediate financial gain resulting from the substitution of mechanical tillage for preparatory hand-forking.

Acknowledgments.

The author is indebted to Mr. G. B. Westwood of the Ste. Madeleine Sugar Co., Ltd., Trinidad, and Mr. J. H. Taylor of Orange Grove Estates, Trinidad, for permission to publish the data on yields and costings; and to Mr. J. A. Potter, who is in charge of Experiment I.

References.

(1) Christidis, B. G. (1931).—The importance of the shape of plot in field experimentation. *Journal of Agricultural Science*, XXI, 14.
(2) van Dyke, Ir. J. (1930).—Tilling for cane planting in Java. *Bul.* No. 23. *Third Conference of International Society of Sugar-Cane Technologists.*
(3) Fisher, R. A. (1928).—Statistical methods for research workers. London.
(4) Fisher, R. A., and Wishart, J. (1930).—The arrangement of field experiments and the statistical reduction of the results. Technical Communication No. 10. *Imperial Bureau of Soil Science*, Rothamsted.
(5) Hardy, F. (1929).—The distribution of textural types. I. Soils of Central Plain. *Minutes and Proceedings of the Froghopper Investigation Committee* II, 243.
(6) Nicoll, J. L. (1930). Soil preparation—ploughing, &c. *Reports of the Association of Hawaiian Technologists*, p. 83.
(7) Rothamsted Reports (1927-28).—pp. 151-152.
,, ,, (1929).—p. 98.
(8) Tempany, H. A. (1927).—Experiments with sugar-cane conducted by the Department of Agriculture in Mauritius. *Bulletin* No. 39, General Series.
(9) Turner, P. E. (1929).—Liming as a factor in the amelioration of deteriorated tropical soils. *Journal of Agricultural Science*, XIX, 83.
(10) Turner, P. E. (1930).—The state of unsaturation of the soil in relation to its field behaviour and lime requirement. *Soil Science*, XXX, 349.
(11) Turner, P. E. (1932).—An analysis of an estate experiment to determine the effect of sulphate of potash on yield of sugar-cane (plant canes), with especial reference to the design of the layout. *Fourth International Congress of Sugar Technologists.* Porto Rico.
(12) Wishart, J. (1931).—The analysis of variance illustrated in its application to a complex agricultural experiment on sugar beet. *Archiv für Pflanzenbau*, V, 38.

COTTON NOTES.

By J. B. Hutchinson.

Inheritance of Corolla Colour in some Indian Cottons.

In this paper Kottur, Mundkur and Maralihalli(1) report on the inheritance of two genes, R and Y, controlling the formation in the corolla of red (anthocyanin) and yellow (flavone) pigments respectively. They confirm Leake's conclusion that the two genes are simply and independently inherited. In conclusion they discuss the inheritance of yellow corolla colour in a cross between *Dharwar* No. 1 and *G. neglectum* var. *rosea* made by the senior author, and reported on in a previous publication (2). These results have already been discussed by Harland (3) and the present writer (Hutchinson (4)).

The position may be briefly reviewed in the light of the data now presented.

Three types are involved in the problem:

(1) *Dharwar* No. 1.
(2) *G. neglectum* var. *rosea*.
(3) *G. sanguineum*.

Cross 1 × 2 was dealt with by Kottur (2), and the crosses 1 × 3 and 2 × 3 are reported in the paper under review.

In F_2 and F_3 of Cross 1 × 2 Kottur reported the occurrence of full yellow, pale yellow (named "light" yellow to avoid confusion by the present writer), and white corolla colours, in proportions which fitted fairly closely a tri-hybrid scheme devised by Harland (3). Harland postulated a basic gene for yellow, for which the letter Y will be used, an intensifier B, raising the corolla colour of plants carrying Y from light to full, and a gene C, inhibiting the action of B. Kottur, Mundkur and Maralihalli (1) consider Harland's scheme unnecessary, and suggests that the light yellows obtained in Cross 1 × 2 are the result of "dilution of colour due to the presence of two factors for white, rr and yy". Since the Cross 1 × 2 is of the genetic constitution

rr YY × rr yy

all plants must be homozygous rr, and segregation into light and full yellow cannot be explained as being in any way dependent on the action of the r gene.

On any Mendelian scheme, light yellows should appear in two out of the three crosses. They have only been recorded from Cross 1 × 2. This may be explained on Harland's (3) theory as modified by the present writer (4). *Dharwar* 1 belonging to the obtusifolium-herbaceum group of Asiatic cottons, differs considerably from the other two parents, which are both varieties of G. arboreum, in modifying factors affecting the amount of yellow pigment in the corolla. In Crosses 1 × 2 and 1 × 3 there will be segregation of these modifiers in F_2 and later generations. In Cross 1 × 2 light yellow modifiers acting on genotypes heterozygous for Y, will produce lighter yellows than the same modifiers acting on genotypes homozygous for Y, and the variation among yellows will consequently be greater than

in Cross 1 × 3, in which all plants are homozygous for Y. In the writer's experience it is very easy to overlook the presence of lighter grades of yellow in families homozygous for Y, unless flowers are graded in the laboratory, whereas in families segregating for Y also, they cannot escape notice in the field. It may be remarked, also, that Kottur (2) reports on the progeny of ten full yellow F_2 plants, and only two of them contained white segregates, whereas of 17 light yellow F_2 plants investigated, nine threw whites in F_3.

In conclusion, it may be suggested that the classification applied to the F_2 and later generations of the cross *Dharwar* 1 × *G. neglectum* var. *rosea* was not very suitable, and the phenotypic division between full yellow and light yellow did not reflect accurately the genotypic diversity of the material. The phenotypic differences observed were in part due to differences in a number of modifying genes and in part to differences between plants homozygous and heterozygous for Y. A careful comparison of F_2 and parental yellows from the cross *Dharwar* 1 × *G. sanguineum* should also reveal the presence of yellows in F_2 lighter in colour than either parent.

References.

1. G. L. Kottur, B. B. Mundkur and S. S. Maralihalli. Inheritance of Corolla Colour in some Indian Cottons. *Indian Jour. of Agric. Sci.*, Vol. I, Part V, 1931.
2. G. L. Kottur. Studies in Inheritance in Cotton. 1. History of a Cross between *G. herbaceum* and *G. neglectum*. *Mem., Dept. Agr., India, Bot. Ser.*, Vol. XII, No. 3, 1923.
3. S. C. Harland. Corolla Colour in the Cotton Plant. *Mem., Cotton Res. Sta., Trinidad*, Series A, Genetics, No. 1, 1929.
4. J. B. Hutchinson. Studies on the Inheritance of Corolla Colour and Petal Size in Asiatic Cottons. *Mem., Cotton Res. Station, Trinidad*, Series A, Genetics, No. 2, 1931.

COFFEE BEAN DISEASE.

Relation of Nematospora Gossypii to the Disease.

By G. B. Wallace, B.Sc., Ph.D. (Edin.)
Mycologist, Tanganyika Territory.

A Disease of coffee beans in Tanganyika Territory was described in *Tropical Agriculture*, Vol. VIII, No. 1 (1931), pp. 14-17. The disease was shown to be due to *Nematospora Coryli* Peglion, but a second species has now been found to be also associated with the disease. This is *N. Gossypii*, which Ashby and Nowell first described from cotton.

Both species are active parasites in coffee beans as in other crops. One economic result of the present record is that a rather wider range of plants become recognised as possible sources of infection to coffee, *i.e.*, the host plants of *N. Gossypii*, cotton, &c. Since the publication of the previous article on this subject, the distribution of the disease has been recognised to extend beyond Tanganyika. *N. Coryli*, as was expected, has been recorded in other parts of East Africa: Hansford (1) observed it in coffee cherries from the Toro District in Uganda, while McDonald states in a personal letter that he has recently found it frequently in different parts of Kenya Colony.

Both species appear to be equally destructive and will doubtless be found to be equally widespread. Cultures made at Morogoro from diseased beans in seven coffee cherries proved to be as follows: one pure *N. Coryli*, one pure *N. Gossypii*, and five mixed infections of both species. That is to say, each species was present in six out of the seven diseased beans. The species present cannot so far be decided from a naked eye observation. These fungi continue to cause very considerable destruction of coffee beans, and in the opinion of the author they are the most serious cause of disease of coffee in Tanganyika. The greatest efforts are being made by officers of the Department of Agriculture, under the guidance of the Entomologist, to control the bug *Antestia-lineaticollis* Stall. which is the only known spreader of the fungi in coffee.

To enable other workers to diagnose the species readily the following observations are given; they should be read in conjunction with the paper on Nematospora species by Ashby and Nowell ("The Fungi of Stigmatomycosis", *Annals of Botany*, Vol. XL, No. 157, January, 1926).

N. Gossypii grows at almost twice the rate of *N. Coryli*, and in a mixed culture, which frequently occurs, the former can be seen extending beyond the latter. Potato agar with one per cent. cane sugar added is the culture medium which has been used. On this medium *N. Gossypii* gives a low even spreading mycelial growth, whereas *N. Coryli* is at first conical and always remains fairly thick and pasty, more opaque, and with only a narrow margin of radiating mycelial growth as seen by the naked eye. For microscopic distinctions Ashby and Nowell's paper should be followed. The discrepancy in spore width between the species in coffee has, however, been found to be more marked than is described for the species by previous authors. The spore width of *N. Gossypii* from coffee has been found to be 1.7μ (1.6-1.9μ) and of *N. Coryli*, 2.8μ (2.3-3.1μ). A striking difference is the abundance of yeast cells in *Coryli* and their absence in *Gossypii*.

Acknowledgment is made to Mr. S. F. Ashby, Mycologist at the Imperial Mycological Institute, Kew, for confirming the indentifications.

(1) Hansford, C. G.—Annual Report of the Mycologist in the Annual Report of The Dept. of Agric. for the year ended 31st December, 1930, Part II, p. 58, Entebbe, 1931.

WEST INDIAN NOTES.

(*Compiled by the Advisory Department of the Imperial College of Tropical Agriculture.*)

The Sugar Industry.

THE reaping of what promises to be the largest crop of sugar-cane in most of the West Indian Islands is proceeding satisfactorily. In some of the Islands the rainy season was prolonged until the end of January, delaying the ripening of the cane and making reaping operations difficult, but by the end of February, in most places, dry weather conditions had set in. The sucrose in cane and the purity of the juice, however, was lower than for a number of previous years.

A useful pamphlet by Messrs. Box, Collens and Warneford, recording "observations on sugar-cane cultivation with suggestions for improvement" has recently been published by the Antigua Government and should be read by all those interested in this subject. Mr. Box has for the past twelve months been engaged on studies in connection with the control of the moth borer in Antigua. Mr. Collens is Government Chemist in Antigua and Mr. Warneford, Agricultural Superintendent.

In the February issue of *Tropical Agriculture* an account is given of an experiment laid down in 1928 for the determination of the optimum dressing of pen manure on plant canes. Another experiment dealing with the effect of a complete fertiliser on plant cane is also described. The authors of this paper point out that there is a limit to what should be spent on pen manure and that the keeping of animals for the sole purpose of increasing the output of pen manure is unsound. The suggestion is made that a moderate dressing of pen manure supplemented by an application of artificial manures is more remunerative than a heavy application of pen manure without artificials. For the first time an attempt has been made to measure the residual effect of applications of pen manure on subsequent crops. Sugar-cane growers should refer to the original paper with this warning that drastic changes in manurial practice should not be undertaken until experiments over a reasonably long period of time have been conducted.

The work of the Barbados Department of Agriculture in controlling the small moth borer *Diatraea* sp., by the mass production of the egg parasite, *Trichogramma minutum* is being closely followed by the other sugar-growing Islands in the West Indies. Dr. J. G. Myers is making another attempt to introduce into Antigua the Cuban parasite, *Lixophaga diatraeae* which he reports is doing excellent work in controlling the moth borer in Cuba and Porto Rico. Previous attempts to introduce it into Barbados and Antigua have not been successful.

Mr. Harold Box has recently paid a visit to St. Kitts and has made an estimate of the damage caused by *Diatraea* in that Island. Mr. Box has suggested that an effort should be made to introduce *Lixophaga* into St. Kitts also.

The Sea Island Cotton Industry.

There is no improvement to record in the outlook for Sea Island cotton. The demand is slow and prices ruling are extremely low. In St. Vincent and Antigua the reduced area planted in August and September, 1931, has suffered through excessive moisture during the growing months and the yield per acre is much below average. Insect pests are also in some cases causing serious losses.

A conference of cotton growers to consider what means should be taken to improve the position of the industry has been called for the first week in April and at the invitation of the Governor of Barbados will meet in that Colony. It is expected that representatives from all the chief cotton growing Islands will attend.

The Arrowroot Industry of St. Vincent.

For many years the position of the arrowroot industry of St. Vincent has been most unsatisfactory. Large stocks on hand in the chief consuming countries have lowered prices and caused considerable losses to the producers. An attempt was made to stimulate demand by setting up an organization in London to deal with the position. After years of hard work the growers in St. Vincent with the invaluable assistance of the West India Committee and the Empire Marketing Board have recently formed an association for marketing the crop. The Colonial Development Committee came to their assistance with a loan of £30,000 and a grant of £3,000, and with this sum warehouses and plants have been erected for dealing with the whole arrowroot crop of St. Vincent.

This association has now completed a year's work and those connected with it have every reason to be satisfied with the results obtained. Admittedly, there is room for further improvement but the progress that has already been made in grading and marketing the produce is most gratifying. The operations of the association are carried on under a special ordinance in which the organization is described in detail.

Co-operative Marketing.

In addition to the facilities provided for the co-operative marketing of arrowroot in St. Vincent, there has recently been formed in Trinidad a co-operative citrus growers association to handle the grapefruit and budded orange crops of the Island. A spacious packing house has been erected close to Port-of-Spain and a washing and sizing power plant has been installed in this building. Fruit of good quality and attractive appearance have been shipped by the association to Great Britain and Canada. A Florida packing house expert has been engaged to direct operations for the first few years.

Of much longer standing in co-operative marketing is the Trinidad Cocoa Planters' Association through which passes fully one-third of the cocoa shipped from Trinidad. This is

probably the most successful of all marketing organizations in the West Indies. Its more recent work in encouraging the formation of co-operative fermentaries among the peasants of Tobago is likely to have far-reaching effects. The Agricultural Departments of other cocoa-growing Islands should follow closely the developments taking place in this connection.

There are several instances of quasi-co-operative marketing organizations in these Islands, mainly run by Government, such as the Cotton Ginneries of St. Vincent and Nevis, and the recently established Government Fruit and Vegetable Marketing Depots, which are doing excellent work in dealing with peasants' crops. It has been suggested that had the cotton growers in the West Indies formed themselves into a co-operative organization for marketing the whole of the Sea Island cotton crop and for purposes of advertisement, the industry would have been in a stronger position than it finds itself in to-day.

The Coconut Industry.

There has been a marked improvement of late in the prices paid for copra and as a number of the Islands are interested in this crop, this upward trend of prices will be most welcome. In many instances however, coconuts have been planted in what are now known to be unsuitable soils and agricultural officers should take careful note, therefore, of the type of soil before advising on the embarking of extensive coconut plantings. Whilst little improvement is to be observed on the field side of coconut cultivation as practised in the West Indies, much attention has been paid in the larger colonies to the manufacturing side. There are in Trinidad two modern plants operating for the manufacture of refined coconut oil and lard. A certain measure of protection has been given these new industries by Government. The laying down of these plants involves a considerable capital expenditure and should only be undertaken when a considerable area of coconuts is in bearing.

The Fruit and Vegetable Industry.

Montserrat and St. Vincent are the two Islands making the heaviest shipments of vegetables for the Canadian market this season. The early shipments realized good prices but the late January and early February shipments fetched disappointingly low prices. As many as 4,000 lugs were shipped from Montserrat by one steamer in February. Such heavy shipments are only made possible by the facilities available for cold storage provided by the Imperial Government through the Colonial Development Fund. Fruit is received each day at the packing houses and placed in cold storage to await shipment.

Mr. A. C. Shill, the marketing officer, has made several visits to the fruit and vegetable exporting Islands during the shipping season and his advice has been at the disposal of the officers in charge at the marketing depots. During March he proceeded to Canada on official business. A heavy shipment of tomatoes was proceeding North by the same opportunity and Mr. Shill was in a position to follow this shipment to its destination and to observe its condition on arrival. During his stay Mr. Shill consulted various interests in Canada, such as brokers, shipping companies and the West India Trade Commissioner.

Mr. Shill has prepared some "Notes on the West Indian Fruit and Vegetable Trade in Canada" and those interested in this industry would do well to secure a copy of this publication from the local agricultural officer, or from the Advisory Department at the College where a few copies are still available.

Tomatoes are being grown for the Canadian market by estates and peasants in most of the Islands. In certain instances, particularly in St. Vincent, methods of cultivation are being improved. On one estate motor drawn implements are used for thoroughly cultivating the soil and a small "Autoculto," a 2½ h.p. motor surface cultivator, is used for producing a dust mulch. The plants are placed in straight rows and several methods of staking are being experimented with. The manurial treatment is generous and in dry weather irrigation water is applied. Under these conditions heavy crops of good quality tomatoes may be looked for.

A report from Montserrat indicates a record shipment of tomatoes by the s.s. *Lady Hawkins* on 16th February. The shipment of 4,287 crates of tomatoes of which 2,755 crates were shipped by one shipper on his own account and the remainder by the Government Marketing Depot was equal in amount to the season's shipment of two years ago. In addition to tomatoes, small lots went forward by the same steamer of string beans, carrots, cucumbers, sweet potatoes and limes.

Livestock.

Interest in the improvement of livestock is being maintained by planters in certain of the Islands; a shipment of thoroughbred pigs has recently been made to America, and an order has been received for a pedigree bull and young stock for St. Lucia.

Miscellaneous Information.

Professor H. A. Ballou, Commissioner of Agriculture, left for Barbados on 21st March to attend the Cotton Growers' Conference.

Mr. A. C. Shill, Marketing Officer, visited most of the fruit and vegetable exporting Islands during February and March and proceeded to Canada on official duty by the s.s. *Lady Hawkins* on 23rd March.

Mr. F. A. Stockdale, Agricultural Adviser to the Colonial Office, during his stay in the West Indies will visit Trinidad, British Guiana, Barbados, the Windward and Leeward Islands, Bermuda, Jamaica and British Honduras, returning to the United Kingdom *via* Trinidad and Barbados.

Mr. G. A. Jones, Assistant Commissioner of Agriculture, paid an official visit to St. Vincent from 28th January to 13th February, and again left Trinidad on 29th February for an extended tour of the Leeward Islands and St. Lucia. He will attend the Cotton Conference in Barbados.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Liming and Fertility.

Although liming or chalking is one of the oldest operations in British agriculture, it is now realised that much land in England is less productive than it might be owing to the neglect of this practice during the past fifty years. Increase in costs and the introduction of artificial manures have probably largely contributed to this falling off in the use of lime, but owing to the heavy dressings originally applied, considerable time has elapsed before the soil has shown signs of losing its fertility. In view of the many failures of crops which can be attributed to a lack of lime, the Ministry of Agriculture has issued an illustrated bulletin (No. 35), entitled *The Use of Lime in Agriculture* (London: H.M. Stationery Office; 6*d*.), which should prove of real practical help to the farmer. The subject is introduced by a survey of the chief functions of lime. An account of the causes and rate of loss of lime from the soil follows, and definite symptoms of both grass and arable land deficient in lime are described. Remedial measures are considered in detail, the comparative values of the various forms of lime and chalk on the market, such as free and slaked lime, carbonate of lime, waste lime products, and lime rich in magnesia being fully discussed. Definite information as to the best quantity to apply is less simple to provide since conditions are so diverse, but advice on general lines is given, and if in any doubt the farmer is recommended to communicate with his county agricultural organiser. — (*Nature*, Vol. CXXVIII, No. 3243, Dec., 1931, p. 1080.)

* * *

The Relation between Iron, Organic Matter and Plant Growth.

Burk, Lineweaver, Horner, and Allison, in a communication to *Science*, Vol. LXXIV, No. 1925, 1931, p. 522, have summarised two papers which they have submitted for publication in *Soil Science*. They conclude from experimental evidence that natural humic acid increases growth primarily, if not entirely, by virtue of the iron it contains. They suggest that the organic fraction and the other inorganic constituents of humic acid are substantially inactive.

A statistical study of the data shows that a given amount of soluble iron gives the same order of growth stimulation independently of whether the iron is added as natural humic acid or as any of its substitution compounds. The proviso is added that the experiments should be allowed to proceed long enough to permit complete physiological assimilation of the iron added. Further, natural humic acid could not be substituted by humic acids prepared synthetically from glucose and containing only traces of iron, or by iron-free synthetic humic acids containing various metals such as Al, Co, Mn, Si, Mo, or P; or by salts of such elements as Al, Co, Mn, Mo, Ni, Zn, Cr, Cu, or Ag, at various concentrations.

Humic acid does not act by directly increasing the availability of constituents normally added to, or present in the medium, such as glucose, oxygen, free or fixed nitrogen, CO_2, Ca, Mg, Na, K, Fe, PO_4, Cl, SO_4, HCO_3, or by affecting the surface tension or viscosity.

Inorganic iron compounds tend in general to precipitate as the pH is increased, but the reverse is the case with humic acid above pH4. Even compounds like ferric citrate in neutral solution precipitate upon long standing, whereas properly prepared humic acids remain soluble indefinitely. The nutritional value of humus and soil organic matter in agricultural practice is generally ascribed to indirect effects upon soil moisture, texture, aeration, &c., but it is possible that a direct nutritional benefit is obtained by rendering the iron more available.

The growth studies in these researches were conducted with the aerobic soil bacterium Azotobacter vinelandii and although the findings apply strictly to this organism only, the authors contend that there are numerous reasons for believing them to apply quite generally to other organisms, in qualitative respects at least.

* * *

Potash from the Dead Sea.

The resources of the British Empire do not include a sufficient supply of potash, but the inclusion of the Dead Sea under British mandate opens up a possible source of this substance. An English company called Palestine Products, Ltd. was formed two years ago for exploiting this area, and the production of potash and bromine is already on a firm basis. The water contains approximately 25 per cent. dissolved salts, but it was found that the maximum concentration is at 220 feet, and therefore the liquid is pumped from this depth into the evaporating pans.

The finished product is sent by lorry to Jerusalem, as a good asphalt road has been built, and then it is carried by rail to Haifa and other seaports. Railway development will be necessary later, but the industry is at present in its infancy. Most enterprises of this kind have to contend with unhealthy conditions, but the Dead Sea area, though extremely hot in summer, is singularly healthy, and on the whole the prospects are very good.—(*Chem. and Ind.*, Vol. LX, No. 52, 1931, p. 1058.)

COLLEGE MEMOIRS.

The following can be obtained on application to the Editor:

Economic Series:

No. 1.—The Sugar Industry of the British West Indies and British Guiana, with special reference to Trinidad	C. Y. Shephard	1*s*.

* * *

Sugar Technology Series:

No. 1.—Cane Syrup ..	R. H. Hurst	1*s*.
No. 2.—Experiments with Final Molasses ..	J. A. McDonald	6*d*.
No. 3.—Sampling of Cane in the Field	J. G. Davies	6*d*

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

COLLEGE NEWS BULLETIN

APRIL, 1932.] [No. 2.

COLLEGE NEWS.

Mr. G. B. Westwood has been co-opted as a Member of the Governing Body of the College.

* * *

Sir James Currie, Chairman of the Governing Body proceeded to the Sudan during January and February to inspect the various activities of the Empire Cotton Growing Corporation in that area.

* * *

The Hon. H. C. Bayles, Treasurer of Trinidad and Tobago and *ex-officio* Member of the Governing Body of the College, has been appointed a Member of the Accounts Committee.

* * *

Mrs. C. W. Wardlaw and child sailed for England by s.s. *Bayano* on 22nd February, and Mrs. D. D. Paterson and child sailed for the same destination by s.s. *Coronado* on 7th March.

* * *

In view of Mr. A. G. Howell's retirement and of the re-organization of the College administrative department, the Governing Body resolved at their 96th Meeting to style Mr. G. G. Gianetti as Registrar, and Mr. W. A. Tansley as Bursar of the College.

* * *

Dr. C. W. Wardlaw, Banana Pathologist, and Dr. L. P. McGuire, Banana Physiologist, sailed on 25th February, per s.s. *Corinthia* for Santos, Brazil, to investigate, at the request of the British Banana Company, a new disease which has broken out on this Company's banana plantations.

* * *

Dr. R. W. Chaney and Dr. Eling Dorf, Geologists to the Carnegie Institution of Washington, visited the College on 2nd February. Both these scientists are collecting information on plant fossils with the object of comparing the vegetation of North and South America.

* * *

Dr. W. H. Thorpe of the Zoological Laboratory, Cambridge, and Mr. E. A. Armstrong arrived on 29th February and will stay five weeks at the College. Dr. Thorpe hopes to collect various entomological specimens and will be helped in this work by Mr. Armstrong.

Mr. F. P. Keppel, President of the Carnegie Corporation, and Mrs. Keppel arrived on 2nd February and spent a week at the College as the guests of the Principal and Mrs. Evans. Mr. Keppel, during his visit, took the opportunity of inspecting the various College activities in which he was much interested.

* * *

The following members of the Staff are expected to proceed on leave this year: Mr. E. E. Cheesman, Professor of Botany and Genetics; Mr. J. G. Davies, Assistant Sugar Technologist; Mr. G. G. Gianetti, Editor-Librarian and Registrar; Mr. G. A. Jones, Assistant Commissioner; Mr. D. D. Paterson, Lecturer in Agriculture; Mr. E. E. Pyke, Botanist to the Cacao Research Scheme; and Mr. P. E. Turner, Lecturer in Chemistry and Soil Science.

* * *

Mr. P. E. Turner, Lecturer in Chemistry and Soil Science, and Mr. J. G. Davies, Assistant Sugar Technologist, left by Pan American Airways on 2nd March to represent the College at the International Congress of Sugar-Cane Technologists in Porto-Rico. Mr. Turner returned on 12th March and Mr. Davies on 19th March. Dr. J. G. Myers, Entomologist in charge of the Biological Control of Insect Pests in the West Indies, left for Porto Rico by the same opportunity to attend the Conference.

* * *

Amongst those who recently visited the College were:—

Sir John Power, Bt., and Lady Power; Major Hubert C. Corlette; Sir Henry J. Wood and Lady Wood; the Earl of Sandwich; Mr. and Mrs. John Ross, Nigeria; Lord and Lady Burnham; Sir William and Lady Jowitt; Mr. J. Vernon Tate, Director of Messrs. Tate & Lyles; Mr. J. Gordon Miller, Director of Caroni Sugar Estates; Mr. George Moody-Stuart, Chairman of the Finance Committee and Governor of the College, and Mr. Mark S. Moody-Stuart; Mr. Hal Stockley, Director of Messrs. Elders & Fyffes Ltd., and Mrs. Stockley; Mr. Vivian F. Gould; Dr. N. Beccari and Dr. G. R. Giglioli of the Instituto Agricolo Coloniale, Florence; Messrs. D. W. Cole, D. W. Black, H. J.

Hamilton, W. G. Wright, from s.s. *New Northland*, Canada; Mr. A. Jacobsson, Sweden; Vice-Admiral W. Tomkinson, Capt. J. F. C. Patterson, and Lieut.-Commander J. P. Gornall of H.M.S. *Hood*; and Mr. R. Wallace.

—o—

Mr. STOCKDALE'S VISIT.

Mr. F. A. Stockdale, Agricultural Adviser to the Colonial Office, visited Trinidad from the 11th to 27th February, and for the greater part of the time made his headquarters at the College, staying with the Principal. Although it was understood that his visit was to be primarily concerned with College affairs, he nevertheless found time to inspect the activities of the Trinidad Department of Agriculture, and was particularly interested in the present condition of the Cacao and Sugar industries of the Colony, having in view the prolonged spell of low commodity prices that have prevailed.

In regard to the College, Mr. Stockdale went very thoroughly into the financial position with the Principal and was able to gauge the results of recent drastic economies that have had to be effected to meet a condition of falling revenues caused by the world wide depression. During his visit he was afforded the opportunity of attending meetings of the College Advisory Committee and of the Academic Board. He was present at a meeting of the Sugar Cane Investigation Committee, with which the College has an intimate connection through its research work, and at several of the field excursions, planned for post-graduate students. Those to River Estate, the Cocoa Planters' Association, the Cotton Research Station and the Waterloo Estates proved to be of particular interest.

Mr. Stockdale and the Principal were the guests of the students at a dinner at the Milner Hostel and an enjoyable evening was spent, the Colonial Adviser showing commendable proficiency with the billiard cue later on in the evening. During the course of his visit he made personal acquaintance with all members of the College Staff and his friendly criticisms and advice were much appreciated. He was good enough to address the Science Club and his lecture on "Agriculture in the East African Colonies" was an admirable description of the kind of problems that face agricultural officers. He left for British Guiana on 27th February, but has promised to make another short visit when he passes through the Colony on 16th and 17th March, *en route* for Bermuda and Jamaica.

G. E.

AGRICULTURAL EXCURSIONS.

Frequent field excursions were organized for Post-Graduate Students during the Lent term. On 18th January, various aspects of the banana crop were studied. The party split up into three groups and each in turn had the opportunity of discussing cultivation and breeding problems with Professor Cheesman, the pathological aspects with Dr. Wardlaw, and ripening and storage questions with Dr. McGuire at the Low Temperature Station.

On 3rd February much was learnt about grapefruit which now promises to develop into an important alternative crop for the Island. A visit was made in the morning to Spring Hill Estate, Tamana. Mr. W. S. E. Barnardo, the owner, who is one of the pioneers of the industry, was good enough to conduct the party around, demonstrating the control of gummosis by inarching and other means, and describing his system of planting, drainage, and fertilizing. After lunch a visit was made to the new packing shed at Laventille. This is the property of the Co-operative Citrus Growers' Association, and is equipped with the latest type of machinery and appliances for washing, drying, grading and packing the fruit. The rules and regulations of the Association afforded an interesting study for the party.

On 10th February the College party were the guests of Sir Norman Lamont at his estate at Palmiste. The morning was spent in seeing the methods used for converting old sugar lands into a cacao plantation and in inspecting the coffee variety plots. A sumptuous lunch was provided and Sir Norman Lamont on replying to the Principal's expression of thanks, gave details of the working of his estates which proved of great interest. Mr. A. R. Foster proposed a vote of thanks to the ladies in a manner that compared favourably with two of his predecessors, Messrs. J. L. Greig and J. Scott. After lunch the coconut areas comprising some 500 acres were visited and it was noted that the baffling disease known as coconut wilt was more or less conspicuous by its absence this year.

The Cotton Research Station of the Empire Cotton Growing Corporation was the scene of the next excursion when Dr. S. C. Harland and Mr. J. B. Hutchinson were good enough to conduct the party round the Department of Genetics. The exhibit of wild cottons and the resultant hybrids with cultivated species proved of particular interest.

A long day was spent on the Waterloo Estates on 19th February and thanks are due to Captain W. F. Watson and Mr. J. L. Reid for the arrangements made. The Adela and Felicity Estates were first visited and the effect of wilt disease on coconuts was discussed. The area consists of rather heavy soils which are evidently excellent for sugar cane but apparently not so well suited for coconuts, a crop which is rather particular in its requirements as regards soil and environment. On other parts of the estate, the tractor equipment for ploughing and cultivating was seen in action, and later on a visit was made to the sugar factory, the copra drying houses and the model dairy.

The annual visit to River Estate was made on 23rd February, and on this occasion as on the two previous excursions, Mr. F. A. Stockdale accompanied the party. The season in Trinidad has on the whole been an unfortunate one for cacao, as the excessive rains in November, December and January, have caused great losses to the young and immature pods. The crop on River Estate, however, showed little prospect of diminution and is a credit to the manager, Mr. R. O'Connor. The only mild criticism that may be ventured is that it appeared to some of the visitors that there was a slight increase in the losses from Rosellinia root disease. Whether this is actually so or not is impossible to say as the route taken may have been through fields that are particularly subject to this disease. One cannot help thinking, however, that more information is needed with regard to the control of this disease. The programme of experiments on this most interesting estate was fully explained by the Director and Staff. The party were entertained to lunch by the Department, and Mr. Wortley during a witty speech in reply to a vote of thanks, referred somewhat pointedly to the "workmanlike attire" of the Principal of the College when proceeding on a College excursion.

G. E.

—o—

TRINIDAD SCIENCE CLUB.

Six meetings of the Trinidad Science Club have been held. On 2nd October, the Hon. G. G. Auchinleck, Director of Agriculture, Gold Coast, addressed the Club on "Agriculture on the Gold Coast", on 12th November, Mr. R. L. Brooks, of the Forestry Department, Trinidad and Tobago, spoke on "The Construction of a Forestry Policy in the Tropics"; on 10th December Mr. G. Evans lectured on "Closer Settlement Problems in Tropical Australia"; on 14th January, Sir Norman Lamont gave an address on "A West Indian Tourist in Ceylon and the East"; on 18th February, Mr. F. A. Stockdale spoke on "Agriculture in East Africa"; and on 17th March, Mr. W. A. Tansley addressed the Club on "The Development of Aviation in the Colonies". The following have been appointed officers of the Club for the year 1931-32:—President: Professor H. A. Ballou; Vice-Presidents: Hon. E. J. Wortley and W. S. E. Barnado; Committee: Professor F. Hardy and Messrs. H. E. Rapsey, R. O. Williams, L. Grant and N. Wright; Hon. Secretary and Treasurer: Mr. F. J. Pound. Meetings of the Club are held monthly in the Main Lecture Room of the Biological Laboratory. Further information may be obtained from the Hon. Secretary and Treasurer.

—o—

COLONIAL APPOINTMENTS.

The following appointments of students in residence at the College during last session have been notified by the Secretary of State for the Colonies:—

Mr. F. A. Squire, Entomologist, British Guiana.

Mr. J. D. Jameson, Agricultural Officer, Uganda.

Mr. W. J. Badcock, Agricultural Officer, Uganda.

Mr. G. D. P. Olds, Agricultural Field Officer, Malaya.

Mr. J. A. Baker, Agricultural Field Officer, Malaya.

Mr. J. N. Clothier, Agricultural Officer, Northern Rhodesia.

Mr. L. E. W. Codd, Plant Breeder, British Guiana.

Mr. W. F. Gwilliam, Inspector of Plants and Produce, Gold Coast.

Mr. W. J. M. Irving, Agricultural Officer, Uganda.

Mr. L. N. H. Larter, Geneticist, Agricultural Department, Jamaica.

Mr. H. B. Stent, Assistant Agricultural Research Officer, Northern Rhodesia.

Mr. T. G. Strangeways, Inspector of Plants and Produce, Gold Coast.

Mr. J. G. M. King, Agricultural Officer, Tanganyika Territory.

Mr. W. T. Dalgarno, Agricultural Instructor, Bahamas.

Mr. T. A. Russell, Plant Pathologist, Bermuda.

Mr. J. E. P. Booth, Agricultural Officer, Kenya.

Mr. R. E. T. Hobbs, Agricultural Officer, Kenya.

Mr. J. C. Eyre, Agricultural Officer, Tanganyika Territory.

Mr. I. W. M. Armstrong Black, Agricultural Chemist, Nyasaland.

DIPLOMA STUDENTS APPOINTMENTS, 1925-1931.

Students from Trinidad.

POTTER, J. A. (1924-27).	Field Officer, Ste. Madeleine Sugar Company, Trinidad.
BAIN, F. M. (1925-28).	Chief Inspector, Plant Protection Ordinance, Department of Agriculture, Trinidad.
ROBINSON, G. K. (1927-30).	Assistant to Froghopper Entomologist, Trinidad.

Students from Barbados.

EVELYN, S. H. (1922-25).	Cotton Research Officer, St. Vincent.
MCINSTRY, A. H. (1922-25).	Assistant to Plant Breeder, Gatooma, Northern Rhodesia.
WILES, D. R. D. (1922-26).	Plant Diseases Inspector, Department of Science and Agriculture, Barbados.
WILLIAMS, C. H. B. (1922-25).	Cane Agronomist, Department of Agriculture, British Guiana.
SPRINGER, H. B. (1923-26).	Scott, Farnell & Co., Trinidad.
BIRKETT, L. S. (1925-28).	Chemist, Reform Estate, Trinidad.
SPENCER, G. E. L. (1925-28).	Field Assistant, Botanical Department, Imperial College of Tropical Agriculture, Trinidad.
GROGAN, H. L. (1926-30).	2nd Chemist, Caroni Sugar Estate, Trinidad.
NICHOLS, A. F. (1927-30).	Assistant Agricultural Superintendent, St. Lucia.

Students from United Kingdom.

DAVIES, J. G. (1923-26).	Assistant Sugar Technologist, Imperial College of Tropical Agriculture, Trinidad.
SHEFFIELD, F. W. (1926-29).	Superintendent, Department of Agriculture, Nigeria, West Africa.

Students from British Guiana.

STEVENS, R. M. (1924-27).	Inspector of Produce, Department of Agriculture, Nigeria, West Africa.
HANOMANSINGH, R. S. (1926-29).	Agricultural Adviser, Department of Agriculture, Trinidad.
CHIN, E. S. A. (1927-30).	Assistant Agricultural Superintendent, Montserrat.
WILLIAMS, J. F. (1927-30).	Assistant Chemist, Booker Brothers (McConnell & Co., Ltd.) British Guiana.
GREGORY, G. B. (1928-31).	Assistant Agricultural Superintendent, St. Kitts.

Student from Windward Islands.

PALMER, A. C. G. (1924-28).	Science Master, Grammar School, Grenada.

Students from Leeward Islands.

MCDONALD, J. A. (1924-27).	Chemist, Cocoa Research Scheme, Imperial College of Tropical Agriculture, Trinidad.
HUGGINS, H. D. (1923-26).	Assistant Agricultural Superintendent, Department of Agriculture, British Guiana.

Note.

Four other Students have secured the Diploma :—Mulloon, V. I. (Trinidad), 1922-26 ; J. de la Bastide (Trinidad), 1927-31 ; Hynam, C. A. S. (Barbados), 1927-30 ; and Aspiazu, M. (Ecuador), 1924-28. No definite information is available about Mulloon or Hynam. J. de la Bastide however is still in residence and M. Aspiazu has returned to Ecuador where he is managing his own properties.

—o—

EMPIRE COTTON GROWING CORPORATION APPOINTMENTS.

Messrs. E. O. Pearson (1929-30) and M. F. Rose (1930-31), Post-Graduate Students, have been appointed by the Empire Cotton Growing Corporation as Assistants to Mr. Parnell, at the Cotton Breeding Station, Barberton, South Africa.

Printed by the Government Printer, Trinidad, B.W.I.

CROP PRODUCTS MANUFACTURE IN 1931.

A series of articles in *The Industrial Chemist*, Vol. VIII, January, 1932, summarise the developments in the chemical industries of Britain and America during the past year, and points of interest to tropical agriculturists are abstracted below.

Oils, Fats, and Soaps.

By Rex Furness, M.Sc., F.I.C.

The British Empire provides about half the world's requirements of oil seeds, nuts, and kernels, and efforts are being made to increase the existing crops and to introduce such oil-bearing plants as the soya bean, and the tung tree. Some success has been attained in the introduction of the Manchuria soya bean into Northern India, South Africa, Australia, and even Britain itself.

The development of tung tree cultivation is still in its infancy, but attempts are being made to establish the tree in many parts of the Empire. Experiments in Burmah, Central India, Madras, Assam, and Africa, show promise of success, but in none of these cases has the work proceeded far enough to justify exploitation on a commercial scale. In New Zealand, however, two companies have commenced large scale planting, and it is planned to put 40,000 acres under cultivation. Experimental results ase entirely favourable, and there is every indication that both soil and climate are well suited to economic tung-oil production.

Large quantities of peanuts (arachis) have been exported from Northern Nigeria, and successful results with the same crop have been obtained in Australia and Southern Rhodesia. Experimental growing of sunflower has been started in New Zealand, Australia, and Rhodesia.

Increased production of vegetable oils in the Empire would serve the dual purpose of aiding the British industries which use oil and fats, and of increasing the economic stability of the various colonies concerned. The rapid developments in the whale-oil industry have had a disturbing effect on the markets, and the fact that the production of whale-oil has risen from 75,000 tons in 1919-20 to an estimated figure of 750,000 tons in 1930-31 is a tribute to the improved methods of whale-oil production. But there is an obvious limit to this manufacture, and it is not likely to become a serious menace to the profitable production of oil-bearing crops.

The preservation of fats and oils during storage has been the subject of research for some time, and recent results show that chemists have gone far towards solving the problem empirically, although the nature and ultimate cause of rancidity are still obscure. Any advance will be of the utmost importance to the manufacturers of tropical crop products.

Improvements have been made in the extraction of oils by means of volatile solvents, and the loss of solvent by evaporation has been prevented by absorption into a silicagel, from which it can be recovered by heating. The former methods of recovery by oil-scrubbing were expensive and inefficient, but the silicagel method gives high recovery at a comparatively small cost.

Rubber.

By S. A. Brazier, M.Sc., F.I.C., F.I.R.I.

The rubber producers are still compelled to market their raw material at a figure below the economic cost of its production. There has been no improvement in the trade during the past year; in fact, the position is even worse, with no immediate signs of recovery. The plantations are steadily decreasing their output, and it is estimated that the 1931 crop will be 30,000 tons less than in 1930, and 80,000 tons less than in 1929. Against this, estimated figures show that the world's rubber consumption in 1931 has been 20,000 tons less than in 1930, and 100,000 tons less than in 1929. It is evident, therefore, that stocks of rubber have increased, and at the present rate of consumption there is enough in stock to last for almost a year. So serious is the position that a low record price of 2½*d*. per lb. was reached in August. The motor industry is the chief user of rubber, but the steady development of motor transport has been counterbalanced by improved methods of tyre manufacture, giving an increased mileage per tyre.

The extended use of rubber for roadways is considered by some authorities to be the most promising development for increasing the consumption of rubber, and great attention is being paid to this possibility.

Research work is still proceeding on the production of synthetic rubber, in spite of the slump. This is accounted for by the fact that the materials obtained have special properties, such as greater resistance to water, oils and chemicals, along with greater ease of vulcanisation.

D. W. D.

LUMINOSITY OF FIRE-FLIES.

Nature, Vol. CXXIX, No. 3248, states that they have received a communication from Mr. Edward T. Dixon of Billy Dun, Half Way Tree, Jamaica, regarding the luminosity of fire-flies in Jamaica. He mentions having observed large numbers of a species of fire-fly emitting flashes of light in rhythmic unison, a feature, it may be added, that has been noted in other lands. In the Jamaican species the flashes were emitted at intervals of just under three seconds duration. Mr. Dixon mentions having seen half an acre or more of a grass field lit up brilliantly by the flashes of fire-flies so that the shrubs and hedges were revealed. During the intervals between the flashes nothing was visible in the prevailing darkness. Little is known regarding the phenomenon, and experimental observations with reference to the co-ordination of light emission by these insects might prove of great interest.

TREND OF THE MARKETS.

[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
28th January ..	6	10½	10	6¾
4th February ..	6	9½	10	6
11th February ..	6	5¼	10	1½
18th February ..	6	6¾	10	3¾
25th February ..	6	3	9	11¾
3rd March ..	6	3	10	0
10th March ..	5	4½	9	1½
12th March (1931)	6	0	9	9

Prices on the whole have shown an easier tendency during the past month. According to *Messrs. C. Czarnikow, Ltd.*, reports of continued differences of opinion between Cuba and Java as to the interpretation of the Chadbourne Agreement in connection with the determination of crop figures and export quotas for the second contract year of the Plan, have caused no little apprehension in market circles with regard to the future of the Agreement. It is believed in Cuba that there should be a more drastic reduction in Java plantings than that already proposed for the 1933 harvest and that Java's export quota should be reduced.

* * *

COCOA.—American manufacturers continue their policy of heaping up supplies at every decline and on the least sign of improvement keep off the market. With such a state of affairs there does not appear to be any immediate prospect of improvement in prices unless business conditions generally improve thus helping consumption. The principal main crop on the Gold Coast has now been practically all harvested and the original estimate of 185,000 tons looks like being exceeded by 10,000 tons. The price for this brand has been quoted at 27*s.* c.i.f. and locally the market has been steady at $7.80 a fanega.—(*By courtesy of the Cocoa Planters' Association, Trinidad.*)

* * *

BANANAS.—The demand is rather poor and wholesalers are said to be carrying heavy stocks. Jamaicas are unchanged at £18 15*s.* per ton, delivered London, or £18 10*s.* delivered nearest railway station. Brazilians are also unchanged at £17 delivered nearest railway station.—(*West India Committee Circular*, 18th February, 1932.)

RUBBER.—Quotations for Plantation Sheet have ranged as follows :

	d.
27th January	3
3rd February	2 13/16
10th February	2¾
17th February	2 11/16
24th February	2 11/16
2nd March	2¼
9th March	2¼
11th March (1931)	4

The market has remained inactive during the past month. The whole situation, according to *Messrs. Symington & Wilson* now depends on what action may be decided upon with regard to British and Dutch co-operation in some effort to bring production into line with consumption.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
29th January ..	5.49	7.35
5th February ..	5.52	7.40
12th February ..	5.59	7.45
19th February (local)	5.95	—
26th February ..	5.75	—
4th March ..	5.73	—
11th March ..	5.51	—
13th March (1931) ..	5.97	9.55

Prices advanced in the middle of last month chiefly owing to a wave of optimism generated by the early prospect of passing into law the United States Federal Reserve Credit Bill, otherwise the changes have not been very significant. Sea Island is quoted at (Good Fair) 5.95*d.* (Good) 6.45*d.* and (Fine) at 7.20*d.*

* * *

COFFEE.—Prices have shown little change during the past month. Costa Rica's new crop is selling well, first size reaching 139*s.* 6*d.* a cwt. Inquiry is very fair for all good coffees.

* * *

TEA.—Latest averages include Ceylon at 11.83*d.* per lb.; Darjeeling 10.91*d.*; Assam 10.20*d.*; Indian 9.86*d.*; Java 7.34*d.* Prices have, on the whole, shown a much easier tendency during the past two months.

* * *

COPRA is very firm and West Indian f.m.s. is £1 7*s.* 6*d.* higher at £17 15*s.* c.i.f. London.—(*West India Committee Circular*, 18th February, 1932.)

* * *

LIME PRODUCTS.—*Lime Oil.* Small sales of Handpressed have been made at 55*s.* Distilled is firmly held but buyers show little interest at the moment. Small sales of *Lime Juice* concentrated have been reported at £5. Jamaica good to fine Raw has been sold at 2*s.* 6*d.* to 2*s.* 9*d.*—(*West India Committee Circular*, 18th February, 1932.)